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OLD RIVER LOW-SILL CONTROL STRUCTURE

DOWNPULL FORCES ON VERTICAL-LIFT GATES

Hydraulic Model Investigation



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Report 1

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PREFACE

This report is one of a series describing results of model studies performed in connection with the design of the Old River control structures. The tests of the proposed spillway gates for the low-sill structure reported herein were authorized by letter from the Mississippi River Commission to the Waterways Experiment Station dated 6 April 1955, subject, "Model Tests of Forces on Gates, Low Sill Structure, Old River Control," and were conducted at the Waterways Experiment Station during the period April-September 1955.

Messrs. E. J. Williams, J. E. Sanders, F. B. Toffaleti, E. H. Eckler, T. E. Stepan, and C. A. Mitchell of the Mississippi River Commission office participated in the planning and direction of the model tests. Personnel of the Hydraulics Division, Waterways Experiment Station, actively engaged in the study were Messrs. F. R. Brown, T. E. Murphy, C. J. Powell, and C. W. Brasfeild, assisted by Mr. James C. Sartor, a student of Louisiana State University doing postgraduate work at the Waterways Experiment Station.

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SUMMARY

Flow through Old River low-sill control structure will be regulated in eleven 44-ft-wide gate bays. The sill for the three center bays will be at elevation -5 ft msl while the sill for the other eight bays will be at elevation 10 ft msl. Flow will be controlled by multiple-leaf, vertical-lift gates, providing a damming height to elevation 67 ft msl. Each gate in the side bays will consist of three 19-ft-high leaves, while each of the three center bays will require three 19-ft-high leaves plus a 15-ft-high leaf. Model tests were made to determine the vertical forces to which the gate leaves will be subjected by the extreme range of headwater and tailwater elevations that may occur at the structure.

A 1:36-scale model of the low-sill structure was tested first and showed that both the 15- and 19-ft gate leaves would bounce violently under normal operating conditions, producing such destructive forces in the suspension system that the elimination of the conditions causing the bouncing assumed primary importance. A 1:60-scale model of one gate leaf was then installed in a glass-sided flume so that flow patterns around the leaf could be observed. These observations established that the bouncing was being caused by periodically fluctuating pressures as evidenced by the alternate formation of vortices off the top and bottom lips of the leaf. Operation of the lower two leaves in each gate bay fastened together and relocation of the air vents eliminated the bouncing. However, the necessity of operating two gate leaves fastened together imposed considerably increased loading on the hoisting apparatus since each leaf will weigh about 80,000 or 90,000 lb. The maximum applied downpull was found to be about 190,000 lb, which, when added to the dry weight of the two gate leaves, would result in a total hoist load of about 370,000 lb. In the model the maximum downpull was reduced by about 100,000 lb by installing a projecting cover plate over the upper horizontal girder, thereby preventing the nappe from impinging upon the lower girders. Wind effects and other unpredictables, however, justify the use of the higher downpull value in selecting the prototype design hoist load.

A brief series of tests performed in a 1:60-scale section model indicated that the maximum pressure differential between the upstream and downstream sides of the gates would be 38 ft of water for a design pool of 54 ft msl and a tailwater of 20 ft msl. If a cover plate is installed over the top girder a minimum pressure of -2 ft of water on the plate may be expected.

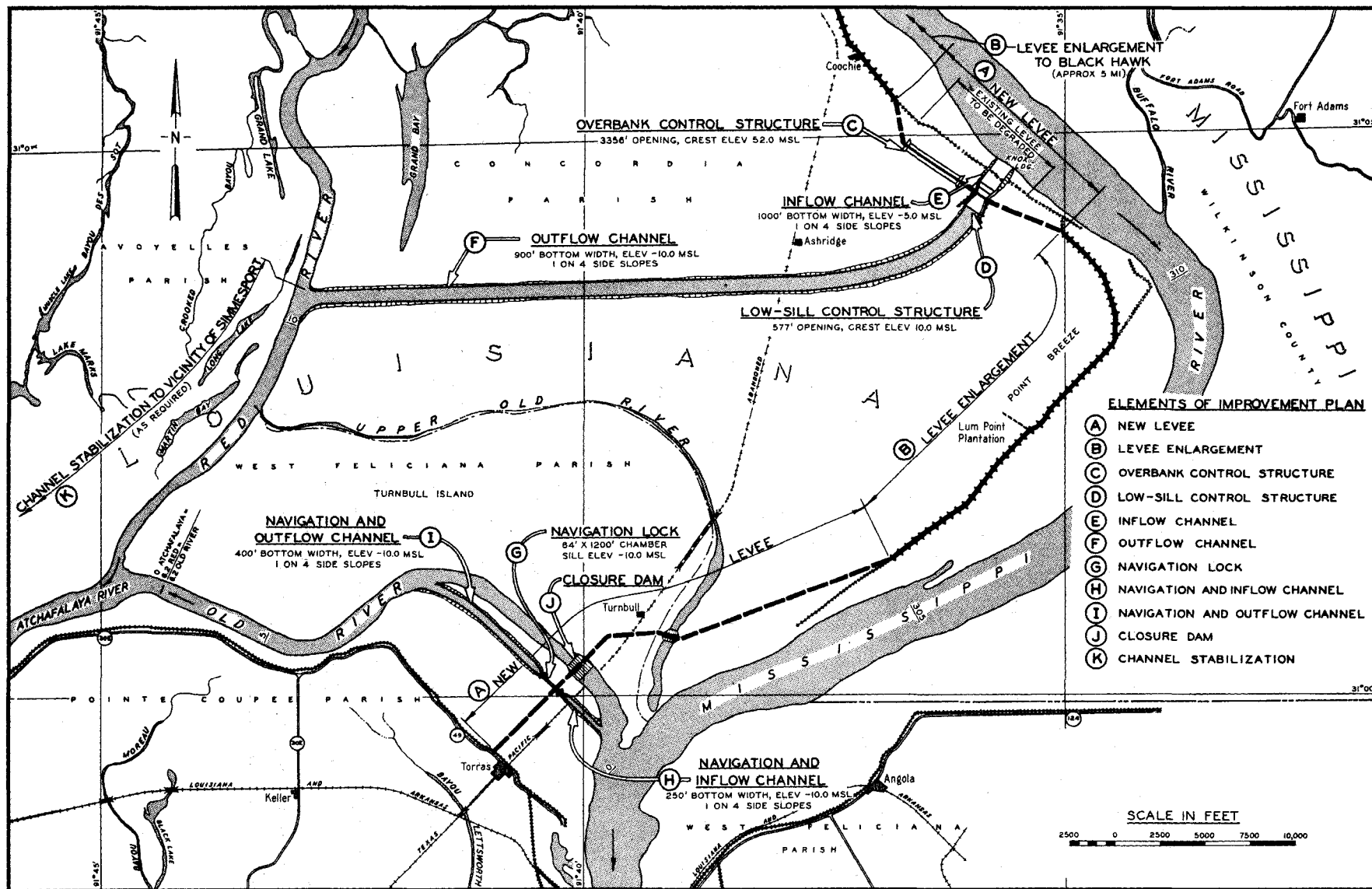


Fig. 1. Plan of improvement

OLD RIVER LOW-SILL CONTROL STRUCTURE
DOWNFULL FORCES ON VERTICAL-LIFT GATES

Hydraulic Model Investigation

PART I: INTRODUCTION

1. The Atchafalaya River, a distributary of the Mississippi through the short connecting channel of Old River, has been increasing in capacity to such an extent as to threaten to divert the Mississippi River through its much shorter and therefore steeper route to the Gulf of Mexico. The following measures are proposed to control flow from the Mississippi and prevent its capture by the Atchafalaya River: closing off the existing Old River channel with a dam and navigation lock; connecting the existing Mississippi River levees above and below Old River; and constructing control structures in the existing Mississippi River levee at a point about 10 miles above the mouth of Old River. The elements of the control plan are shown on fig. 1. The proposed control structures include a low-sill structure 548.5 ft long for the regulation of normal flows and an overbank structure approximately 3393 ft long having a sill elevation of 52 ft* for operation during flood flows. The tests reported herein were concerned with the control gates for the low-sill structure, and constitute one phase of the model studies of this structure.

Description of Prototype

2. The low-sill control structure will consist of eleven 44-ft-wide bays, numbered 1 to 11 from left to right looking downstream. The center three bays will have a sill elevation of -5 ft; the four bays on each side of the low center section will have a sill elevation of +10 ft (figs. 2 and 3). Flow through the structure is to be

* All elevations are referred to mean sea level.

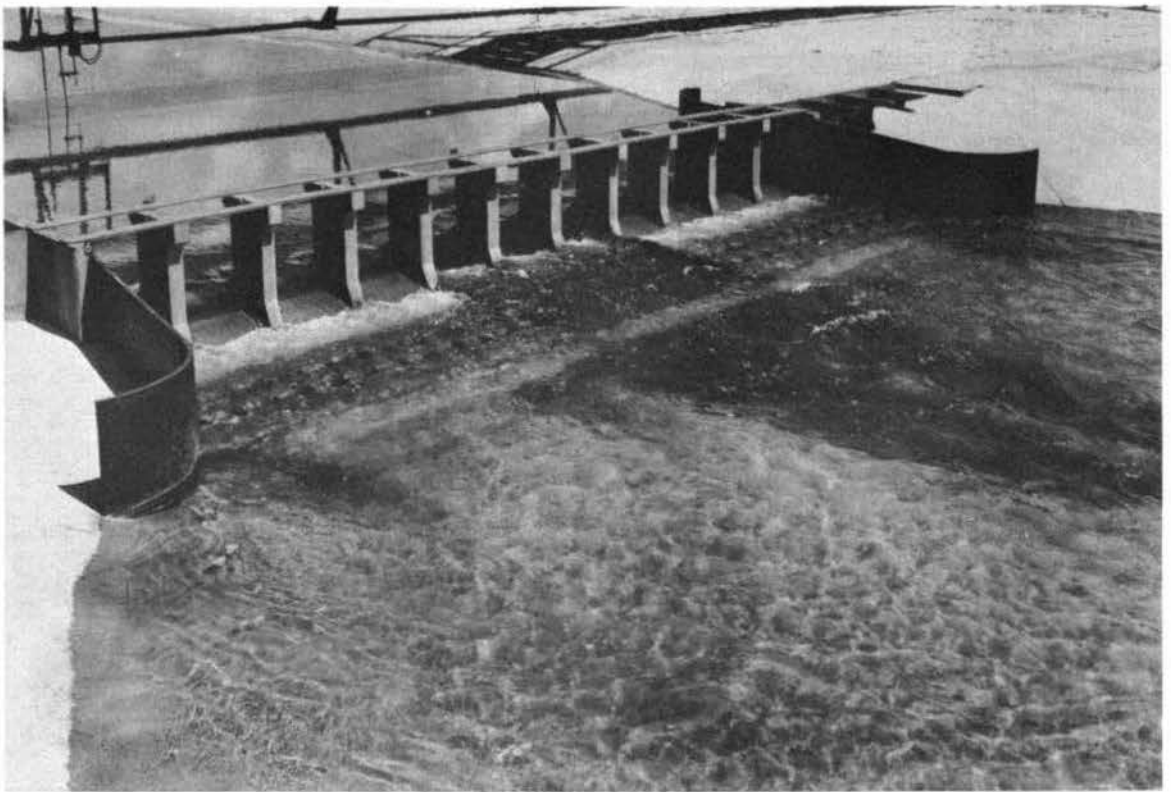


Fig. 2. Low-sill control structure, looking upstream

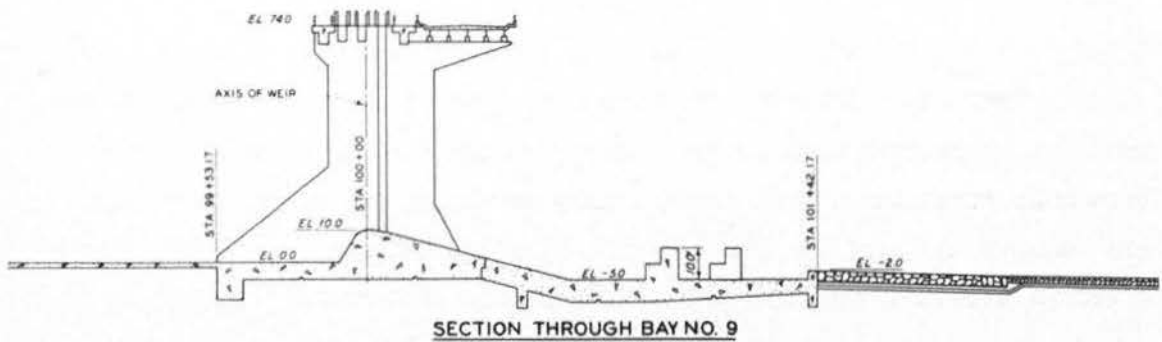
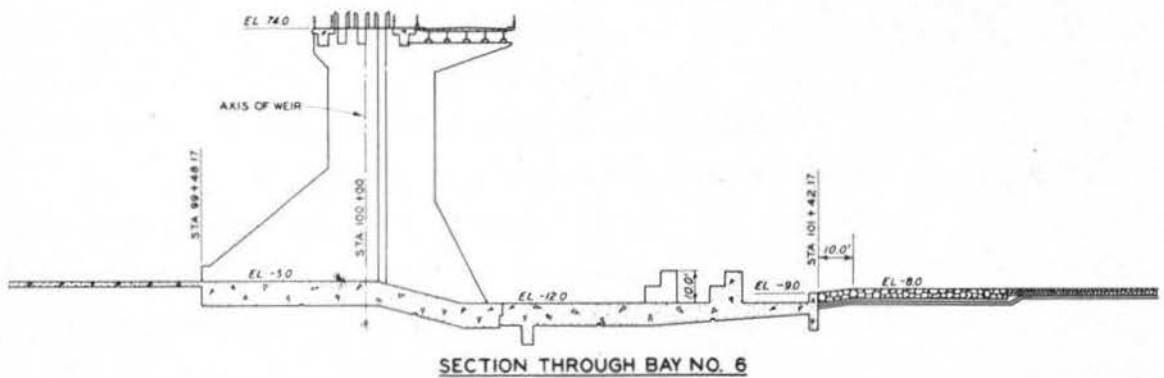


Fig. 3. Sections through operating bays

controlled by multiple-leaf, vertical-lift gates. The gate leaves will be of plate girder construction with a skinplate on the upstream side. The skinplate will extend beyond the upper and lower girders to prevent impingement of flow on the structural members of the gate (see fig. 4).

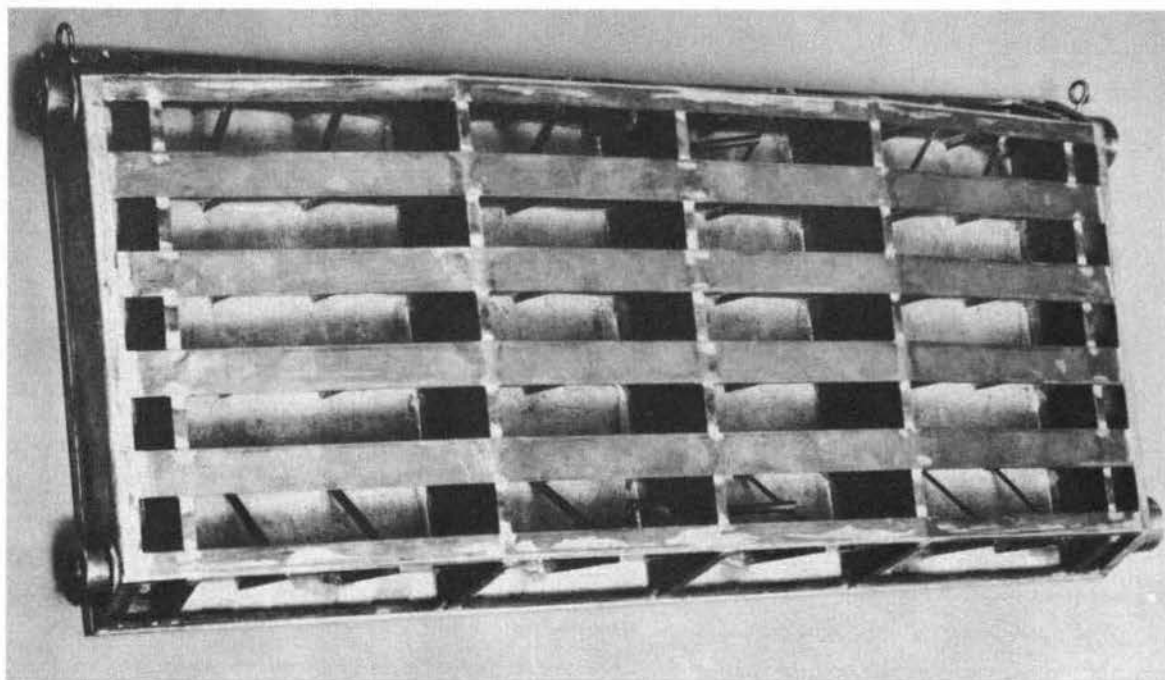
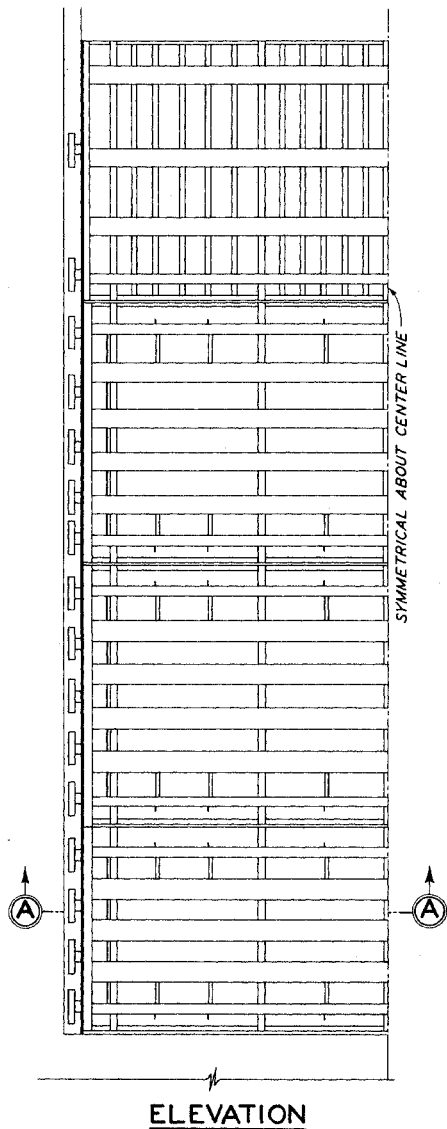
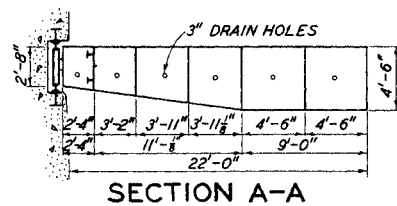
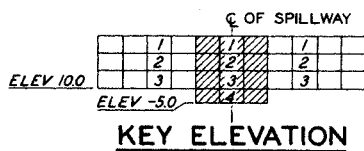
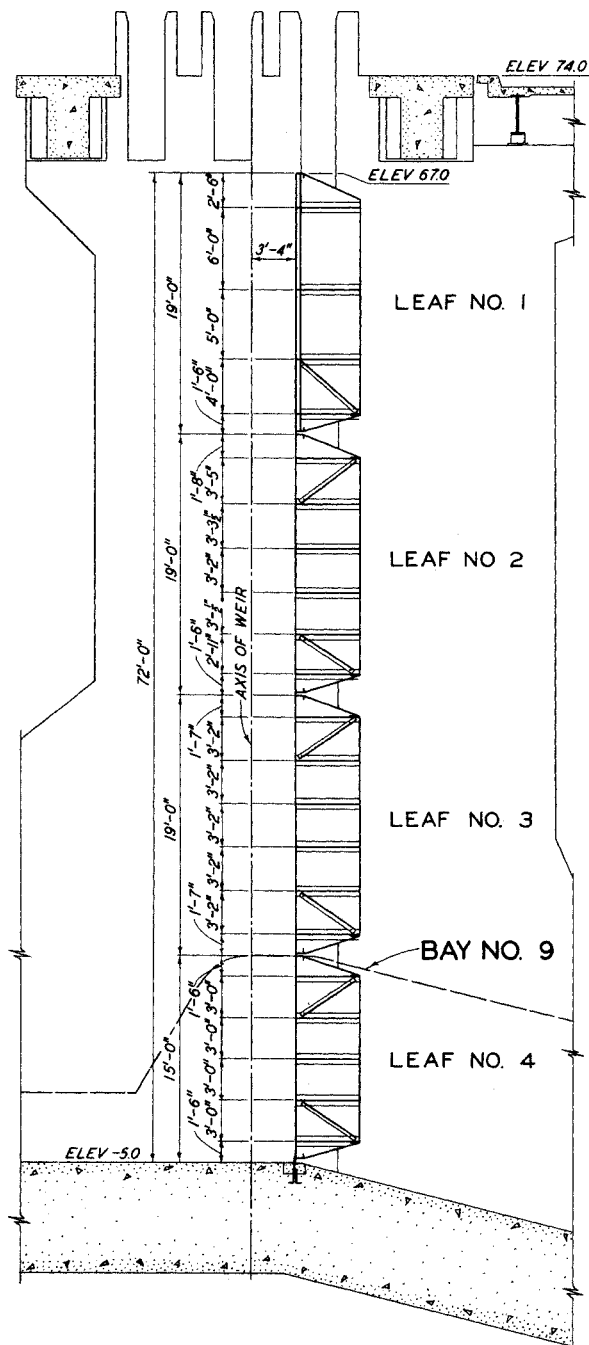


Fig. 4. Downstream side of gate leaf 3 (19 ft high)
showing structural details

3. The arrangement of the gate leaves is shown on fig. 5. One 15-ft leaf is at the bottom position in the low section of the weir with three 19-ft leaves above it. The arrangement is the same for the higher weir section except that the bottom 15-ft leaf is eliminated. It is anticipated that any individual bay either will be operated with all leaves removed or will be completely closed. Individual gate leaves will be raised or lowered by means of a gantry crane on tracks on top of the piers and as each leaf is removed it will be stored in slots provided on top of the piers. It may be necessary to open or close the gates under any of the possible flow conditions up to and including a pool elevation of 67 ft. This means that it will be possible for all except the top gate leaves to have water flowing both over and under them during their removal.



NOTE: SECTION A-A TYPICAL FOR GATE LEAVES NO. 3 AND 4.



Fig. 5. Structural details of gate leaves

Purpose of Study

4. The gate downpull tests were initiated for the purpose of determining the vertical forces to which the gate leaves will be subjected during severe operating conditions so that the suspension system and hoist machinery can be designed for the maximum loading. Since the possible range of headwater and tailwater elevations is extreme, it was deemed necessary to explore this subject with a degree of accuracy that could be obtained only by model tests.

PART II: THE MODELS AND TEST PROCEDURE

Description of the Models

5. A 1:36-scale comprehensive model of the low-sill control structure, a 1:60-scale model of one gate leaf, and a 1:60-scale reproduction of a gate bay, the two adjacent piers, and two gate leaves were used in the study. True similarity between the models and the prototype was obtained by preserving geometric similarity in accordance with the Froudian relationship which assumes gravity as the dominant flow factor. The resulting scale relationships are as follow:

<u>Dimension</u>	<u>General</u>	<u>1:36 Scale</u>	<u>1:60 Scale</u>
Length	L_r	1:36	1:60
Area	$A_r = L_r^2$	1:1296	1:3600
Velocity	$V_r = L_r^{1/2}$	1:6	1:7.75
Time	$T_r = L_r^{1/2}$	1:6	1:7.75
Pressure	$P_r = L_r$	1:36	1:60
Discharge	$Q_r = L_r^{5/2}$	1:7776	1:27885

6. All of the gate downpull tests were performed in the 1:36-scale comprehensive model. Bay 6, the center bay in the low section of the weir, and bay 9 in the high section of the weir were used for all of the tests. Machined aluminum gate slots were installed in the sides of the wooden piers flanking bays 6 and 9 so that the gate rollers would encounter a negligible amount of friction. In these tests pool and tail-water elevations were set by means of staff gages on the abutments and no effort was made to measure discharge.

7. The downpull measuring apparatus (fig. 6) consisted of two pulleys mounted above the gate slots, two flexible brass cables supporting the gate and passing up over the pulleys, a Hunter type spring scale graduated to 0.1 lb at which the two cables terminated, and a hand winch attached to the Hunter gage by means of a single cable of flexible brass

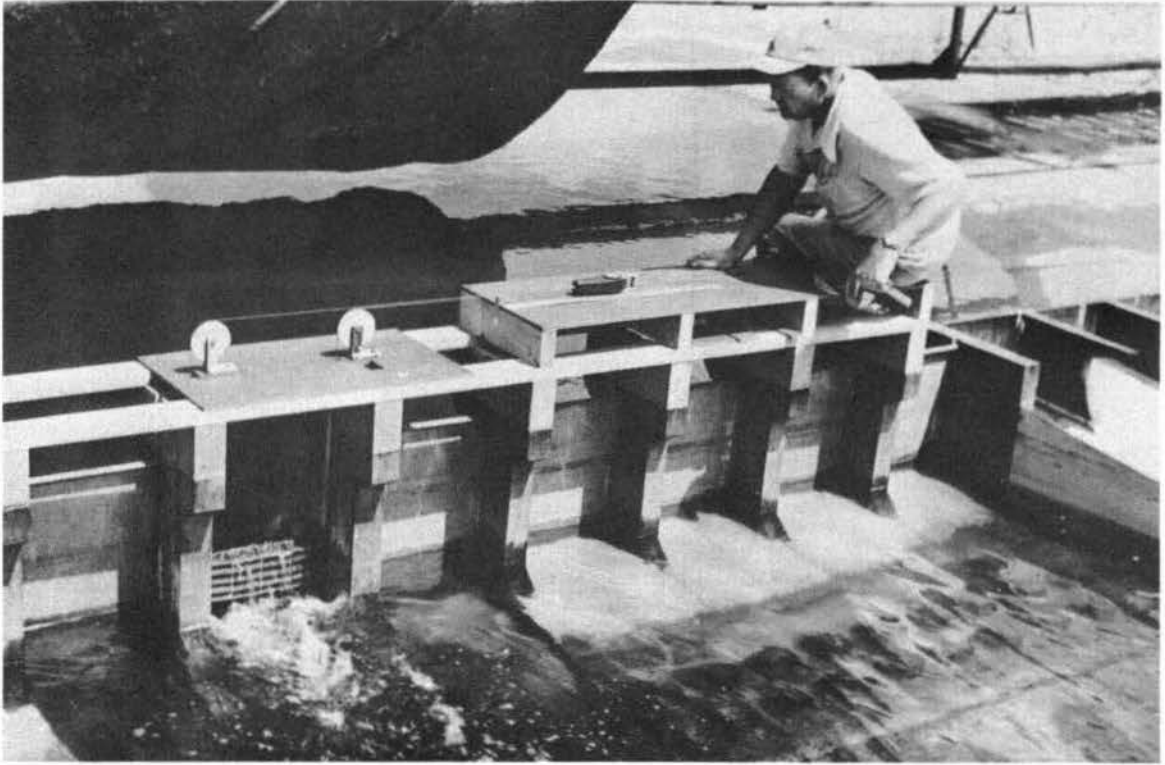


Fig. 6. Gate leaf 4 being tested in bay 6. The gate is at the position of maximum downpull

wire. A miniature turnbuckle was mounted in one of the cables supporting the gate leaf so that the leaf could be leveled accurately when installed in the slots. The pulleys, which were ball-bearing mounted, were adjustable for both height and alignment so that they would be in line with the hoisting cables and so that the two cables would subtend a minimum angle where they were connected to the Hunter gage.

8. The 1:60-scale model of a single leaf was installed in an existing glass-sided flume for visual study of flow patterns. This gate leaf consisted of a block of wood equal in thickness and height to the over-all dimensions of the gate leaf. The portions of the skinplate extending beyond the upper and lower girders forming the gate lips were fabricated of sheet metal. The model was one foot wide (60 ft prototype) and of uniform cross section; therefore it was not an exact reproduction of a gate leaf but only of the cross section of the center portion of the leaf. This installation is shown on fig. 7.

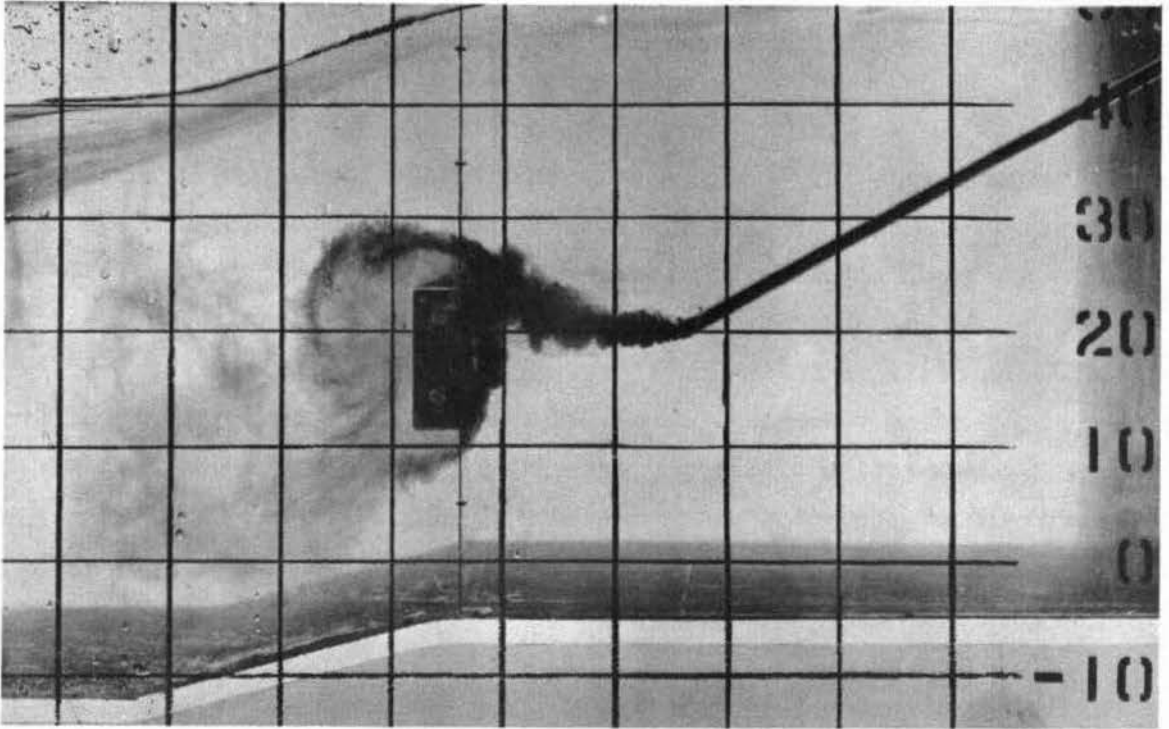


Fig. 7. A section of the 15-ft-high gate leaf mounted in the glass-sided flume. A vortex can be seen forming at the top lip of the gate

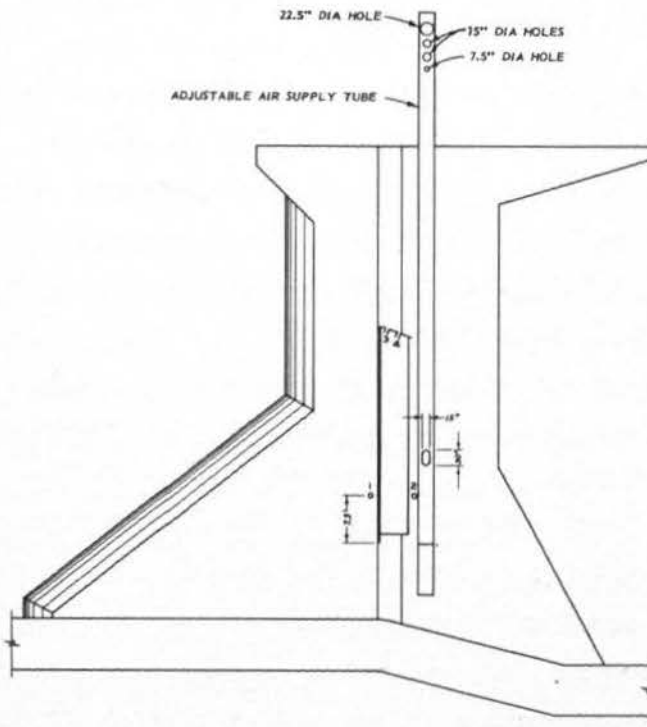


Fig. 8. Piezometer locations and air vents

9. A simple, skeletal, sheetmetal, 1:60-scale reproduction of two gate leaves with a cover plate over the top girder was used for determination of pressures upstream and downstream from the gate and on the top surface of the cover plate. This model reproduced bay 6 and the piers on each side. Details of the installation and the location of piezometers are shown on fig. 8.

Method of Operation - Downpull Tests

10. When a gate leaf was installed in the slots for testing it was checked immediately for levelness and freedom from binding throughout the range of operation. All tests were conducted with the gate leaves closing and an initial downpull reading was taken either just as the lower lip of the leaf came in contact with the nappe or with the leaf at its highest position if the pool elevation was too high for the leaf to clear the surface. Normally, downpull readings were taken at each 5-ft interval of elevation thereafter except that an additional reading was always taken at the point where the nappe just overtopped the leaf. This was usually the position of maximum downpull and was caused by the very thin nappe clinging to the edge of the top girder and falling on the lower girders.

11. The openings at which bouncing occurred were noted and operation was discontinued at those points. The term "bouncing" indicates rapid and destructive alternating vertical movement of the leaf of up to 40 ft prototype. Frequently there was a tendency to bounce, that is the leaf would bounce if initial oscillations were set up by jiggling the supporting cables. Under certain flow conditions the downpull readings fluctuated widely and rather rapidly at some particular gate opening but the leaf could not be induced to bounce. In those cases, maximum, minimum, and observed average readings were recorded. Since it was very difficult to take these readings accurately, the data recorded in such cases should be considered as approximate. The gate leaves were always tested to the fully closed position except in those cases where the weight of the leaf was not sufficient to cause complete closure.

PART III: TESTS AND RESULTS

12. A series of 84 complete downpull tests was performed; the results obtained are summarized in table 1. The program involved the testing of a number of gate designs, operation of from one to three gate bays, operation of individual as well as attached gate leaves, and operation with a wide variety of headwater-tailwater combinations. Features of the different designs are shown on plate 1. All of these tests were performed with the air vents at the original elevations of 8, 21, 34, and 47 ft.

13. Initial tests with gate leaves 3 and 4 in their normal positions in bay 6 (see plates 2-17) revealed that, under certain river stages, leaf 4 would bounce violently. Leaf 3 exhibited a tendency to bounce at a tailwater of 40 ft and a headwater of 55 or 60 ft. The magnitude of the cable stress induced by this bouncing was such as to cause the small brass wire hooks, by which the cables were affixed to the leaf, to straighten out. In order to avoid further damage to the gate a model operator caught the leaf as soon as bouncing started. Under these conditions it was impossible to measure the maximum downpull that occurred; however, it is known that the downpull exceeded five times the weight of the gate leaf at times. The degree of elasticity of the suspension seemed to have little effect since bouncing occurred even with the spring scale removed from the system.

14. At this point testing of the 1:60-scale section model of the outline of the 15-ft gate leaf was initiated so that flow patterns could be observed. Violent flow conditions ensued with headwater and tailwater elevations comparable to those which had caused bouncing in the 1:36-scale model. The nappe just downstream from the gate oscillated up and down rapidly, thereby creating an audible slapping sound. At the same time vortices could be seen forming alternately at the upper and lower lips of the gate leaf in resonance with the flapping action of the nappe. A length of hollow glass tubing was held so that the lower end was adjacent to the lower lip of the gate leaf. The water column in this tube fluctuated with the same frequency as the formation of the

vortices. Air introduced under the nappe increased the frequency of vortex formation and apparently reduced the amplitude but did not eliminate pressure fluctuations, thus indicating that modifications to the air vents alone would not guarantee freedom from bouncing. The air vent size was varied (see fig. 8) but no noticeable change in flow conditions resulted; thus the original 15-in.-diameter vents were considered to be adequate for all air demands. Honeycombing the skinplate with holes above the top girder failed to prevent formation of the vortices. High-speed motion pictures were taken which show the vortex formation clearly; one vortex can be seen forming at the top lip of the gate leaf on fig. 7.

15. The phenomenon of alternate vortex formation at the sides of a cylinder immersed in flowing water was first described by Strouhal* in the formula:

$$S = \frac{fD}{V}$$

where:

S = dimensionless "Strouhal number"

f = frequency

D = diameter of cylinder

V = velocity of fluid past cylinder.

This formula was derived from observations only. Some years later, von Kármán* made a theoretical analysis of the subject which led to the development of a formula for the magnitude of the alternating force associated with the vortex formation:

$$F_K = C_K \rho \frac{V^2}{2} A$$

where:

F_K = Kármán force (normal to flow)

C_K = Kármán coefficient (approximately 1)

ρ = density of fluid

V = velocity of fluid past cylinder

A = projected area of obstacle (normal to flow).

* J. P. den Hartog, "Recent technical manifestations of von Kármán's vortex wake," Proc., Nat. Acad. of Sc. of U.S.A., vol 40, No. 3, 1954.

Application of the latter formula to the case of the Old River vertical lift gate results in an alternating force considerably less than the dry weight of the gate except for the condition of maximum headwater-tailwater combination. Den Hartog* states that the Kármán force is greater for a cylinder that is vibrating at the Strouhal frequency than for one that is at rest, and it is believed that this principle applied in the bouncing of the gate. Apparently the alternating Kármán force was large enough to set the gate in motion, since the cable suspension was somewhat elastic; and once motion had begun, the magnitude of the alternating force and the amplitude of the bounce each increased in a manner of mutual excitation.

16. Rouse** states that the Strouhal number for a flat plate immersed in flowing water with the plane of the plate normal to the direction of flow is approximately $1/7$. Since the Old River gate installation was analagous to this situation (see fig. 9), the Strouhal formula was used to compute the theoretical vortex formation frequencies for gate leaf heights of 15, 25, and 35 ft (see fig. 10). Actual observations of the 1:60-scale model showed that the vortices were forming at the

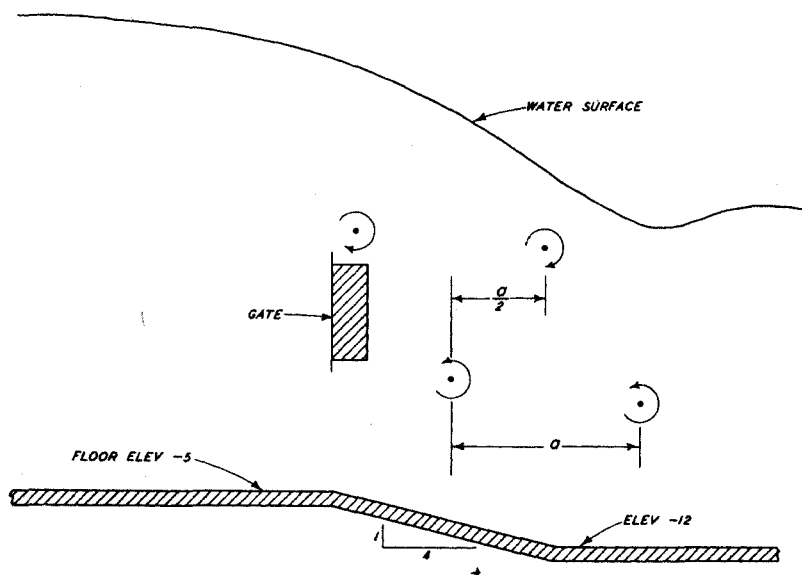


Fig. 9

* J. P. den Hartog, op. cit.

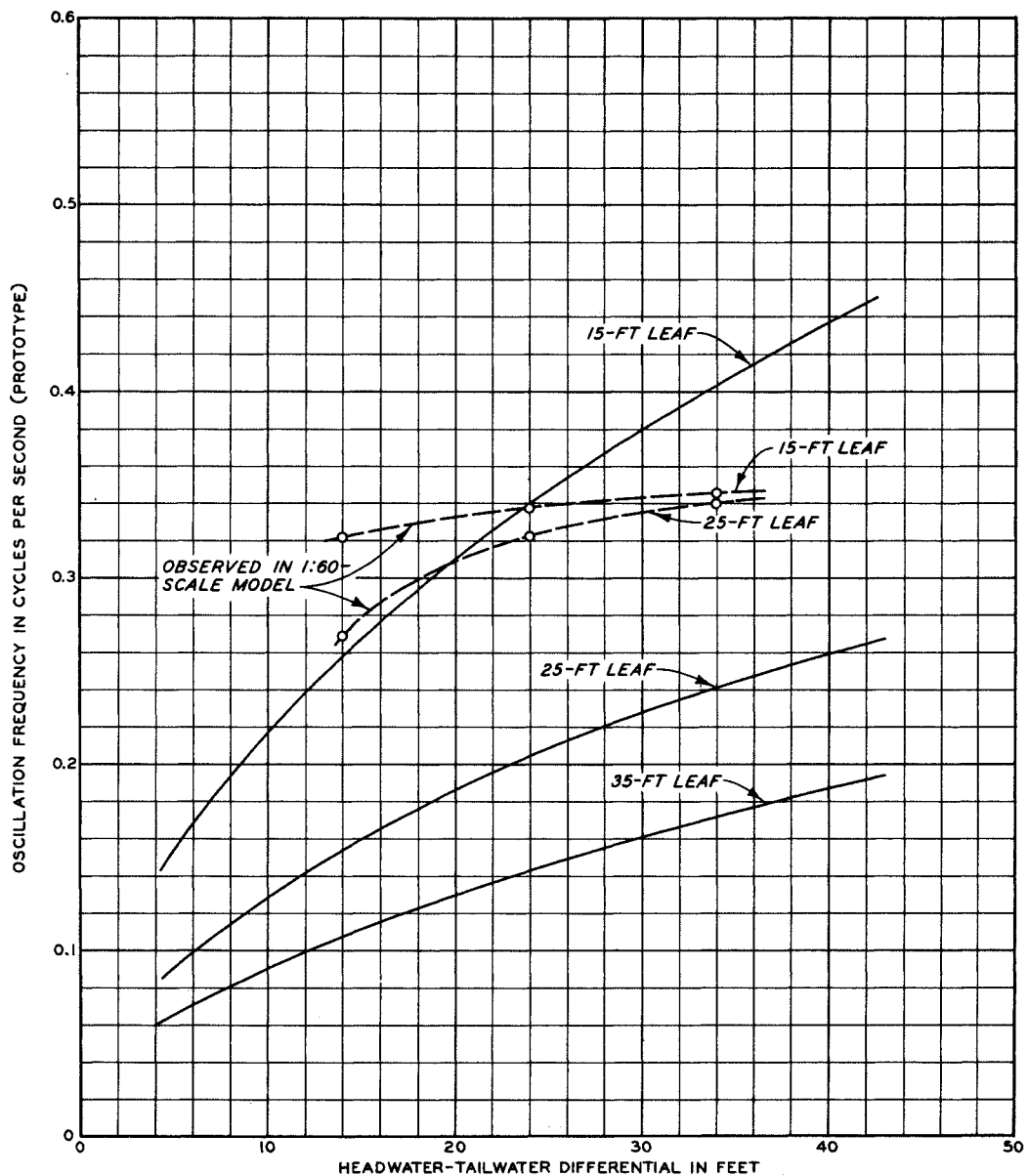
** Hunter Rouse, Elementary Mechanics of Fluids, John Wiley & Sons, Inc.

Addition to paragraph 15:

Actual determination of transverse forces resulting from flow past immersed bodies of various shapes is difficult. Several authors^{† ‡} have indicated that the lateral or transverse forces can exceed the drag or longitudinal force by a factor of from 2 to 4.

[†] Hunter Rouse, Engineering Hydraulics, New York, John Wiley & Sons, Inc. (1950).

[‡] L. Landweber, Flow about a Pair of Adjacent, Parallel Cylinders Normal to a Stream, Report No. 485, David Taylor Model Basin (July 1942).



NOTE: CURVES SHOWN AS SOLID LINES WERE
COMPUTED FROM THE FORMULA:

$$f = \frac{V}{7L}$$

WHERE:

f = FREQUENCY IN CPS

$V = 0.9\sqrt{2gh}$

L = LEAF HEIGHT IN FEET

h = HEADWATER-TAILWATER IN FEET

Fig. 10. Vortex frequencies

frequencies shown by the dashed curves of fig. 10 for 15- and 25-ft leaf heights. Since model operation was at Reynolds numbers for which the Strouhal formula should apply, it is believed that external factors and nonsymmetrical velocity distribution around the gate were responsible for the rather wide divergence from theoretical frequencies.

17. Since no way had been found to eliminate the vortices in the small-scale section model, the first revisions to be tried in the 1:36-scale comprehensive model were directed toward reducing the alternating force effect upon the gate leaf. Types 1-A and 1-B gates (see plate 1) incorporated 1.5- and 3.0-ft extensions to the upper and lower lips of the leaves but failed to eliminate bouncing as shown on plates 18-23. When the leaf was reversed in the slots so that the skinplate was on the downstream side, it either bounced as in the case of type 1-R or failed to close of its own weight as with types 1-A-R and 1-B-R (see plates 24-31). A skinplate from the top lip to the back of the top girder (type 2) did not eliminate bouncing (see plates 32-34).

18. The fact that the gate leaf bounce was being caused by circulation around the leaf led to the belief that if the leaf height were increased, damping effects might be increased and bouncing eliminated. Leaf 3, which was 19 ft high, was first tried in the No. 4 position but the tendency to bounce persisted. The next step was to fasten leaves 3 and 4 together and to operate them as a single 34-ft-high leaf. This arrangement eliminated bouncing throughout the range of operation and a tendency to bounce occurred only at the 54-ft-pool and 40-ft-tailwater combination with the three center bays in operation. The results of this series of tests are shown on plates 35-60. All of these tests were performed using gate leaves of the original design.

19. When installed in gate bay 9 in the high section of the weir, gate leaf 3, which occupied the bottom position, bounced at tailwater elevations above 25 ft. Gate leaves 3 and 4 operating as a single 34-ft-high leaf (installed in the positions of leaves 2 and 3, respectively) eliminated bouncing just as they had done in bay 6. Since the gate will be 38 ft high with leaves 2 and 3 fastened together, these test results are on the safe side (see plates 61-80).

20. Throughout the tests just described the maximum downpull force for most test conditions had been about 100,000 to 190,000 lb with two gates leaves of original design joined together. A few additional tests were performed to determine whether or not this force could be reduced by extending the bottom lip or by placing a cover plate over the top girder of the top gate leaf. Type 1-C incorporating the lower lip extension and type 2-C which utilized a plate extending only as far downstream as the edge of the girder did not reduce downpull but types 2-A and 2-B with overhanging cover plates were quite effective. Since the effect of the overhanging plates was to prevent the jet from falling back in on the lower girders, and since this condition probably would not occur in the prototype except in high winds, the value of the cover plate is questionable (see plates 81-84).

21. The addition of cover plates caused the gate to bounce under certain conditions for the 67-ft-pool and 40-ft-tailwater combination. This led to the opinion that the gate of original design might also be somewhat susceptible to bouncing under the same conditions. For this reason the original test, the results of which are shown on plate 50, was rerun and the results are shown on plate 85. It was found that the gate would bounce at a 15-ft opening if it were allowed to stay in that position for a sufficient length of time. Deaeration of the nappe caused the bouncing to start; consequently the air vents, originally located at el 8, 21, 34, and 47 ft, were relocated at el 28, 34, 40, and 47 ft so as to be more effective, and the bouncing was eliminated for all designs and stages with the two bottom leaves operating together.

22. A short series of tests was performed on the 1:60-scale section model to determine the maximum pressure differential between the upstream and downstream sides of the gate and the maximum negative pressures on a cover plate with a 6-in. overhang on the downstream side of the gate. Details of the installation are shown on fig. 8. It was found that the maximum differential between piezometers 1 and 2 for design conditions was 38 ft of water. The maximum negative pressure reading on piezometer 3 was -2.0 ft of water and on piezometer 4, -1.3 ft. These negative pressures were read at a head just low enough to prevent the jet from springing free of the cover plate.

PART IV: CONCLUSIONS

23. The proposed design of the vertical lift gates is entirely satisfactory provided the two bottom gate leaves are fastened together and are operated as one unit. The air vents in the three center bays should be relocated at el 28, 34, 40, and 47 ft to insure elimination of the tendency of the gate leaves to bounce. Under these conditions, the maximum hoist load per bay will be about 370,000 lb.

Table 1
Summary of Results
1:36-scale Comprehensive Model

Plate No.	Gate Leaf No.	Leaf Design	Features of Design	Pool El	TW El	Maximum Downpull K	At Gate Opening*	Maximum Uplift K	At Gate Opening*	Gate Bounces	At Gate Opening*
2	3	1	Original design, leaf No. 4 in place	60	40	62.5	30	26.0	10	Tendency	21-14
3	3	1	Original design, leaf No. 4 in place	55	40	58.0	25	31.0	15	Tendency	16-9
4	3	1	Original design, leaf No. 4 in place	50	40	44.0	20	30.8	10	No	-----
5	3	1	Original design, leaf No. 4 in place	45	40	16.0	16	35.5	10	No	-----
6	3	1	Original design, leaf No. 4 in place	45	20	100.0	16	None	--	No	-----
7	3	1	Original design, leaf No. 4 in place	40	20	100.0	11	None	--	No	-----
8	3	1	Original design, leaf No. 4 in place	35	20	86.0	5	None	--	No	-----
9	3	1	Original design, leaf No. 4 in place	30	20	30.0	0.2	None	--	No	-----
10	4	1	Original design	56	40	44.3	40	25.8	25	Yes	20
11	4	1	Original design	50	40	44.1	38.5	25.8	25	Tendency	5-0
12	4	1	Original design	45	40	7.0	35	25.8	20	No	-----
13	4	1	Original design	45	20	62.8	30	None	--	Yes	10
14	4	1	Original design	40	20	67.5	28	None	--	Yes	10
15	4	1	Original design	35	20	67.5	23	None	--	Yes	10
16	4	1	Original design	30	20	44.3	20	25.8	10	Yes	8
17	4	1	Original design	25	20	25.5	15	21.0	10	No	-----
18	4	1-A	Original design, gate lips extended 1.5 ft	60	40	57.2	45	12.8	20	No	-----
19	4	1-A	Original design, gate lips extended 1.5 ft	50	40	34.0	37	26.7	25-10	No	-----
20	4	1-A	Original design, gate lips extended 1.5 ft	40	20	61.8	26	12.8	10	Yes	8
21	4	1-B	Original design, gate lips extended 3.0 ft	60	40	59.3	42	29.2	5	Tendency	20-10
22	4	1-B	Original design, gate lips extended 3.0 ft	50	40	17.3	34	48.0	10	Tendency	20-10
23	4	1-B	Original design, gate lips extended 3.0 ft	40	20	82.6	23	10.7	10	No	-----
24	4	1-R	Original design, skinplate on up-stream side	45	20	184.2	20	None	--	Yes	11
25	4	1-R	Original design, skinplate on up-stream side	40	20	160.6	20	None	--	Yes	11
26	4	1-A-R	1-A design, skinplate on upstream side	60	40	271.8	40	50.0	5	Floats	4.5
27	4	1-A-R	1-A design, skinplate on upstream side	50	40	122.5	36	55.0	5	Floats	4.5
28	4	1-A-R	1-A design, skinplate on upstream side	40	20	225.0	15	----	--	Floats	4.5
29	4	1-B-R	1-B design, skinplate on upstream side	60	40	194.5	43	62.0	5	Floats	4.5
30	4	1-B-R	1-B design, skinplate on upstream side	50	40	110.5	25	48.0	5	Floats	4.5
31	4	1-B-R	1-B design, skinplate on upstream side	40	20	194.5	24	----	--	Floats	3.0
32	4	2	Original design, skinplate over top girder	60	40	60.0	48	42.7	25	Tendency	30-5
33	4	2	Original design, skinplate over top girder	50	40	32.0	38	43.7	25	Tendency	20-5
34	4	2	Original design, skinplate over top girder	40	20	64.7	28	None	--	Yes	12
35	3	1	Original design, leaf No. 4 removed	60	40	77.5	45	44.0	5	Tendency	15-10
36	3	1	Original design, leaf No. 4 removed	50	40	30.8	34	53.5	27	No	15-10
37	3	1	Original design, leaf No. 4 removed	40	20	77.5	24	39.3	5	Yes, air vents closed	10
38	3, 4	1	Leaves 3 and 4 joined, center bay operating	67	65	13.5	60	28.5	30	No	-----
39	3, 4	1	Leaves 3 and 4 joined, center bay operating	67	60	13.5	37	51.8	30	No	-----
40	3, 4	1	Leaves 3 and 4 joined, center bay operating	67	55	27.5	36	37.8	20	No	-----
41	3, 4	1	Leaves 3 and 4 joined, center bay operating	67	50	60.0	37	52.3	15-10	No	-----
42	3, 4	1	Leaves 3 and 4 joined, center bay operating	67	45	65.0	35	51.8	15	No	-----
43	3, 4	1	Leaves 3 and 4 joined, center bay operating	67	40	101.8	36	61.5	15	No	-----
44	3, 4	1	Leaves 3 and 4 joined, center bay operating	60	40	55.0	30	56.8	15	No	-----
45	3, 4	1	Leaves 3 and 4 joined, center 3 bays operating	67	65	4.2	60	23.7	30-5	No	-----
46	3, 4	1	Leaves 3 and 4 joined, center 3 bays operating	67	60	23.0	36	33.0	30	No	-----
47	3, 4	1	Leaves 3 and 4 joined, center 3 bays operating	67	55	55.5	37	28.5	20-15	No	-----
48	3, 4	1	Leaves 3 and 4 joined, center 3 bays operating	67	50	60.3	37	65.8	25	No	-----
49	3, 4	1	Leaves 3 and 4 joined, center 3 bays operating	67	45	139.5	36	42.5	15	No	-----
50	3, 4	1	Leaves 3 and 4 joined, center 3 bays operating	67	40	172.2	35	42.5	5	No	-----
51	3, 4	1	Leaves 3 and 4 joined, center 3 bays operating	60	40	120.8	32	42.5	10	No	-----
52	3, 4	1	Original design, center bay (No. 6) operating	54	40	55.8	24	37.5	10	No	-----
53	3, 4	1	Original design, center bay (No. 6) operating	54	30	107.3	24	14.2	5	No	-----
54	3, 4	1	Original design, center bay (No. 6) operating	54	20	181.8	24	None	--	No	-----

* Gate opening measured in feet from bottom lip of operating gate to sill or to top lip of next lower gate when installed.

Table 1 (Continued)

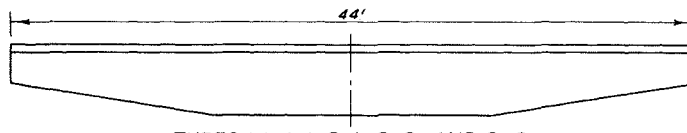
Plate No.	Gate Leaf No.	Leaf Design	Features of Design	Pool El	TW El	Maximum Downpull K	At Gate Opening*	Maximum Uplift K	At Gate Opening*	Gate Bounces	At Gate Opening*
55	3, 4	1	Original design, center bay (No. 6) operating	40	20	79.2	11	4.9	1	No	-----
56	3, 4	1	Original design, bays Nos. 5 and 6 operating	54	20	144.5	24	None	--	No	-----
57	3, 4	1	Original design, bays Nos. 5, 6, and 7 operating	54	40	83.9	25	51.5	15	Tendency	15-10
58	3, 4	1	Original design, bays Nos. 5, 6, and 7 operating	54	30	139.8	24	4.9	5	No	-----
59	3, 4	1	Original design, bays Nos. 5, 6, and 7 operating	54	20	186.5	24	None	--	No	-----
60	3, 4	1	Original design, bays Nos. 5, 6, and 7 operating	40	20	121.2	10	None	--	No	-----
61	3	1	Original design, bay No. 9 (high weir) operating	54	45	58.7	25	53.4	15	Yes	15
62	3	1	Original design, bay No. 9 (high weir) operating	54	35	86.7	24	None	--	Yes	10
63	3	1	Original design, bay No. 9 (high weir) operating	54	25	91.4	24	16.7	5	No	-----
64	3	1	Original design, bay No. 9 (high weir) operating	40	20	82.0	10	None	--	No	-----
65	3, 4**	1	Original design, bay No. 9 (high weir) operating	67	54	42.0	21	51.5	10	No	-----
66	3, 4**	1	Original design, bay No. 9 (high weir) operating	67	45	116.5	21	23.5	2	No	-----
67	3, 4**	1	Original design, bay No. 9 (high weir) operating	67	35	125.9	22	9.4	5-2	No	-----
68	3, 4**	1	Original design, bay No. 9 (high weir) operating	67	25	181.9	21	4.9	25	No	-----
69	3, 4**	1	Original design, bay No. 9 (high weir) operating	54	45	28.0	9	33.0	2	No	-----
70	3, 4**	1	Original design, bay No. 9 (high weir) operating	54	35	74.8	9	23.5	2	No	-----
71	3, 4**	1	Original design, bay No. 9 (high weir) operating	54	25	121.2	9	None	--	No	-----
72	3, 4**	1	Original design, bay No. 9 (high weir) operating	54	20	149.2	9	None	--	No	-----
73	3, 4**	1	Original design, bays Nos. 8, 9, and 10 operating	67	55	52.0	20	74.7	10	No	-----
74	3, 4**	1	Original design, bays Nos. 8, 9, and 10 operating	67	45	149.2	23	32.9	2	No	-----
75	3, 4**	1	Original design, bays Nos. 8, 9, and 10 operating	67	35	139.5	23	None	--	No	-----
76	3, 4**	1	Original design, bays Nos. 8, 9, and 10 operating	67	25	176.8	22	None	--	No	-----
77	3, 4**	1	Original design, bays Nos. 8, 9, and 10 operating	54	45	51.0	10	19.1	2	No	-----
78	3, 4**	1	Original design, bays Nos. 8, 9, and 10 operating	54	35	167.5	10	None	--	No	-----
79	3, 4**	1	Original design, bays Nos. 8, 9, and 10 operating	54	25	176.8	10	None	--	No	-----
80	3, 4**	1	Original design, bays Nos. 8, 9, and 10 operating	54	20	190.8	12	None	--	No	-----
81	3 4	1 1-C	Lower gate has 4.5-ft lower lip extensions; bays Nos. 5, 6, and 7 operating	67	40	184.1	32	26.0	5-2	No	-----
82	3 4	2-A 1	Cover plate over top girder with 1.5-ft straight extension; bays Nos. 5, 6, and 7 operating	67	40	73.3	35	66.8	10	Yes, when nappe is not aerated	15
83	3 4	2-B 1	Cover plate over top girder with 1.5-ft haunched extension; bays Nos. 5, 6, and 7 operating	67	40	64.8	35	47.4	5-2	Yes, when nappe is not aerated	15
84	3 4	2-C 1	Cover plate over top girder, no extension; bays Nos. 5, 6, and 7 operating	67	40	151.3	37	44.7	5-2	Yes, when nappe is not aerated	15
85	3, 4	1	Original design; rerun of test shown on plate 50	67	40	167.3	37	38.0	5	Yes, when nappe is not aerated	15

Note: All tests were conducted with center bay only in operation unless otherwise stated.

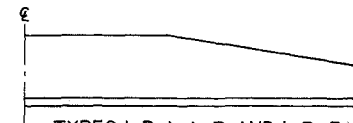
Whenever two gate leaves were used, they were joined and operated as a single gate.

* Gate opening measured in feet from bottom lip of operating gate to sill or to top lip of next lower gate when installed.

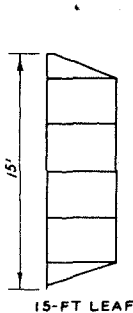
** Leaves Nos. 3 and 4 were used in lieu of leaves Nos. 2 and 3 and occupied positions 2 and 3, respectively. With leaves joined, total height was 34 ft instead of 38 ft.



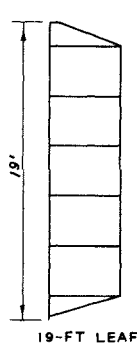
TYPES 1, 1-A, 1-B, 1-C, 2, AND 2-C
PLAN VIEW



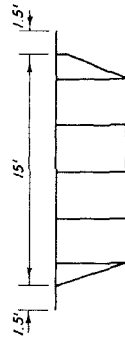
TYPES 1-R, 1-A-R, AND 1-B-R
HALF PLAN VIEW



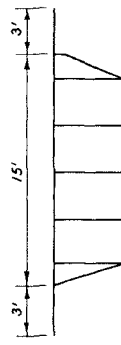
15-FT LEAF



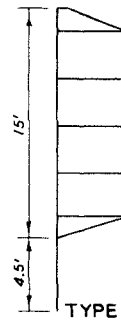
19-FT LEAF



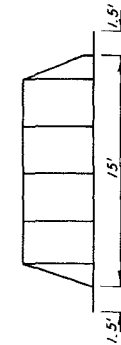
TYPE 1-A



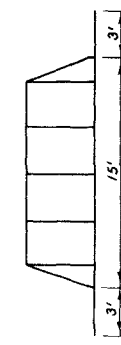
TYPE 1-B



TYPE 1-C



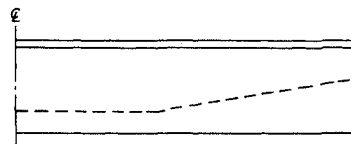
TYPE 1-A-R



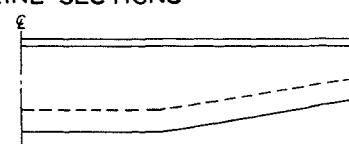
TYPE 1-B-R

TYPE 1

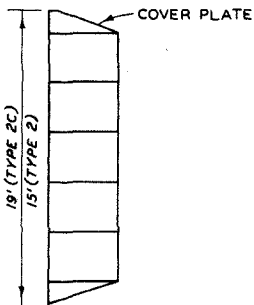
CENTER-LINE SECTIONS



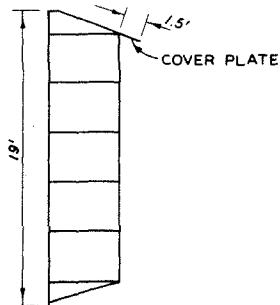
TYPE 2-A
HALF PLAN VIEW



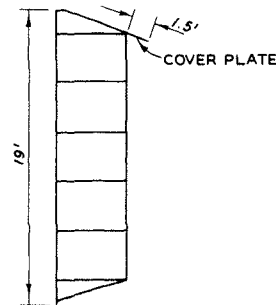
TYPE 2-B
HALF PLAN VIEW



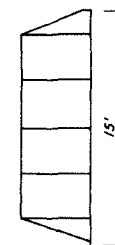
TYPES 2 AND 2-C



TYPE 2-A
CENTER-LINE SECTIONS

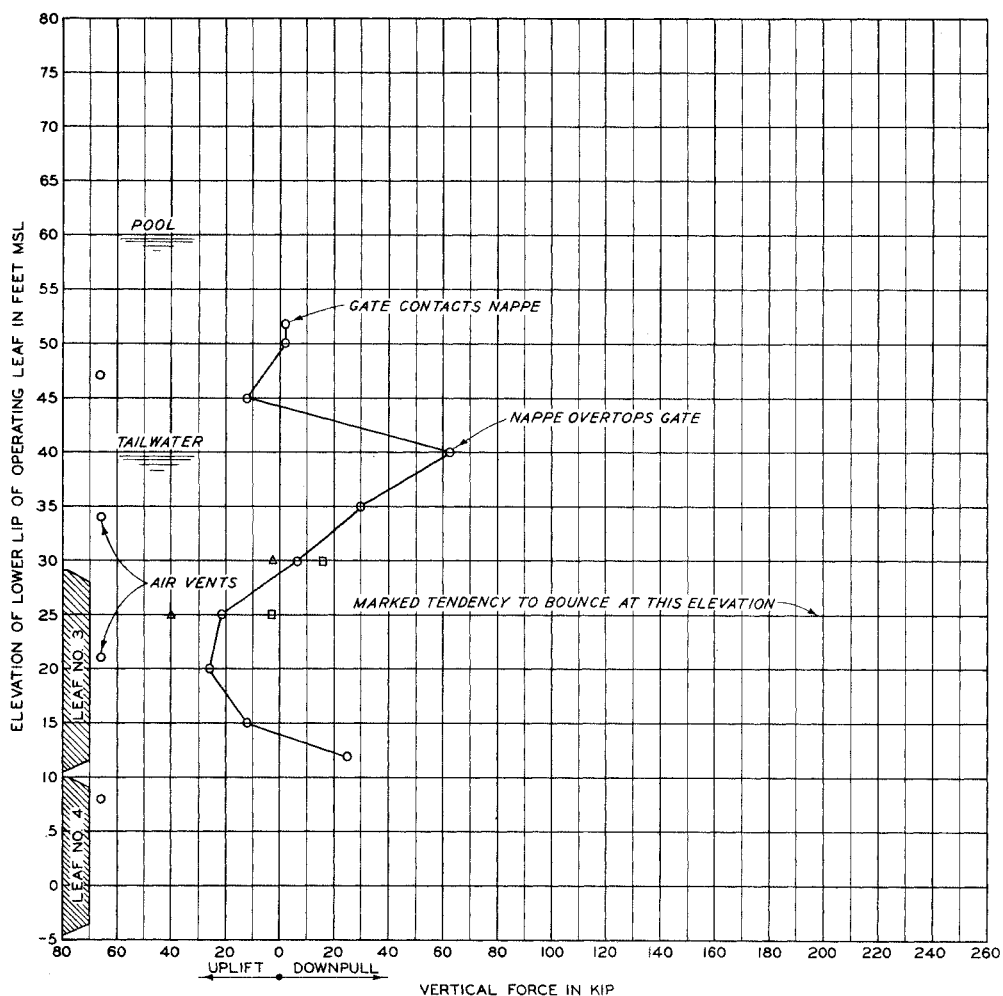


TYPE 2-B



TYPE 1-R

GATE TYPES



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

VERTICAL FORCES PLOTTED ARE EXTERNAL FORCES ACTING UPON THE GATE AS A RESULT OF FLOW OVER AND UNDER IT. IN ORDER TO OBTAIN THE TOTAL HOIST LOAD, THE DRY WEIGHT OF THE GATE SHOULD BE APPLIED TO THE FORCES SHOWN.

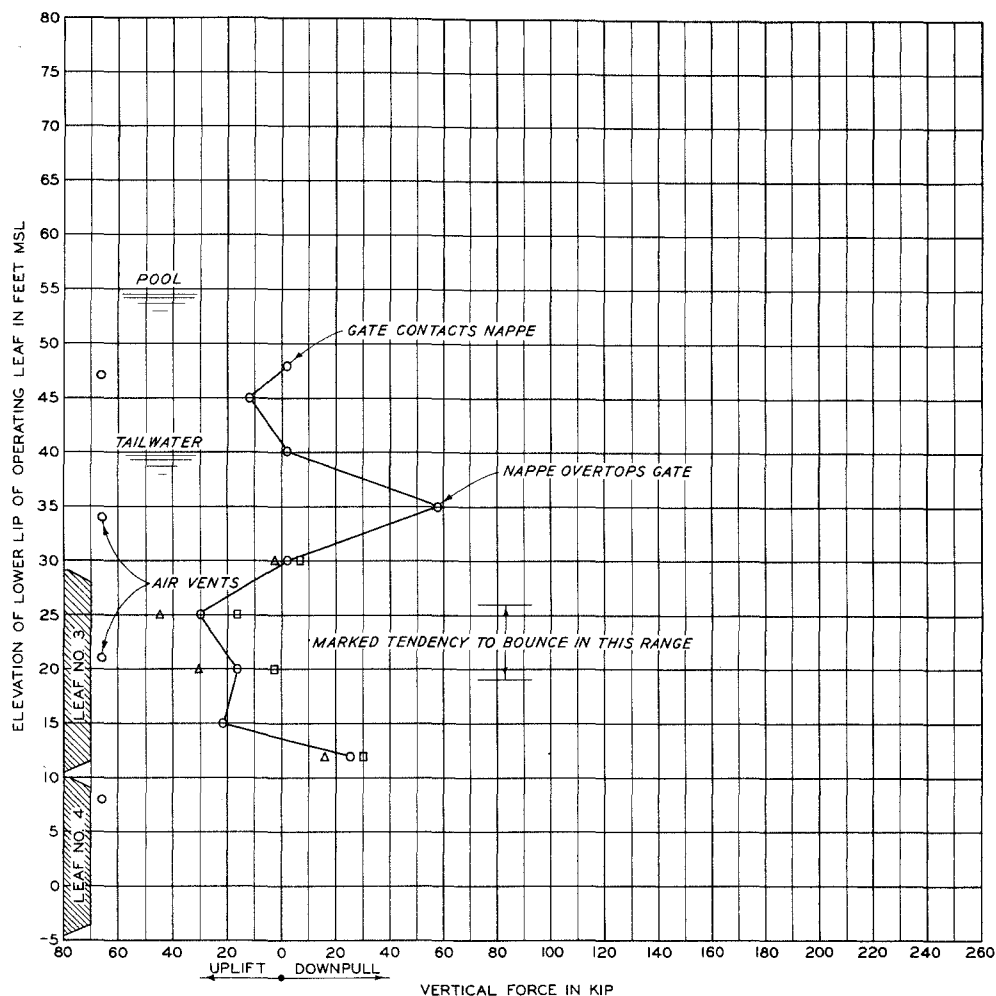
ALL BAYS CLOSED EXCEPT CENTER BAY (BAY NO. 6).

LEGEND

- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 CLOSING
GATE LEAF NO. 4 IN PLACE
POOL ELEV 60.0 FT MSL
TAILWATER ELEV 40.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

VERTICAL FORCES PLOTTED ARE EXTERNAL FORCES ACTING UPON THE GATE AS A RESULT OF FLOW OVER AND UNDER IT. IN ORDER TO OBTAIN THE TOTAL HOIST LOAD, THE DRY WEIGHT OF THE GATE SHOULD BE APPLIED TO THE FORCES SHOWN.

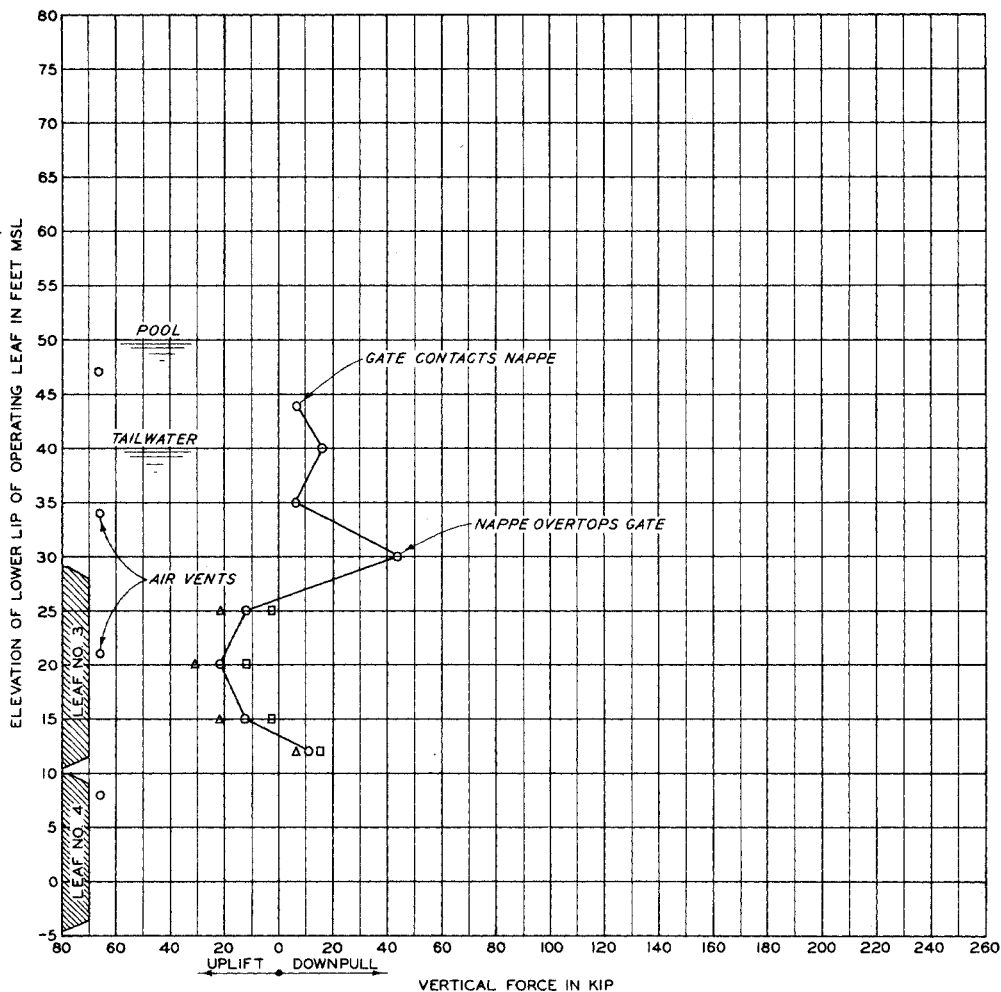
ALL BAYS CLOSED EXCEPT CENTER BAY (BAY NO. 6).

LEGEND

- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 CLOSING
GATE LEAF NO. 4 IN PLACE
POOL ELEV 55.0 FT MSL
TAILWATER ELEV 40.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

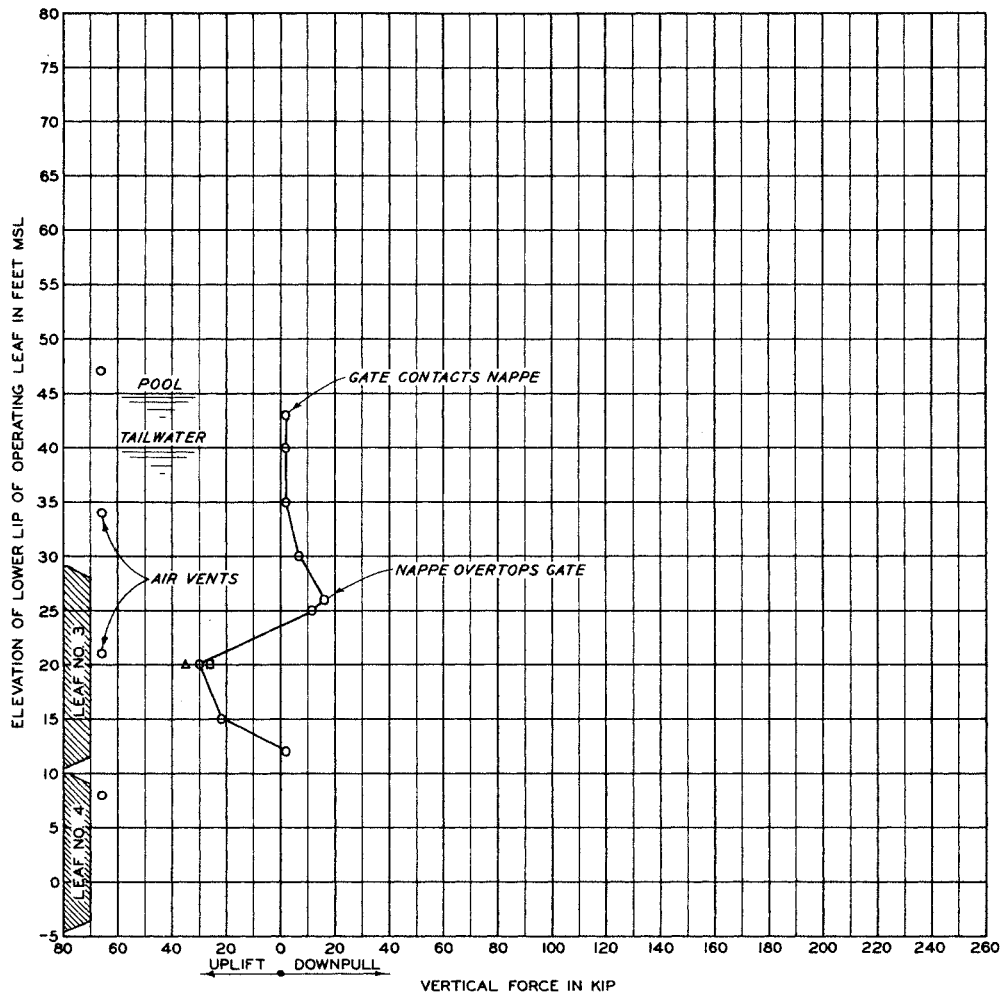
VERTICAL FORCES PLOTTED ARE EXTERNAL FORCES ACTING UPON THE GATE AS A RESULT OF FLOW OVER AND UNDER IT. IN ORDER TO OBTAIN THE TOTAL HOIST LOAD, THE DRY WEIGHT OF THE GATE SHOULD BE APPLIED TO THE FORCES SHOWN.

ALL BAYS CLOSED EXCEPT CENTER BAY (BAY NO. 6)

LEGEND
 O OBSERVED AVERAGE
 □ MAXIMUM
 △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 CLOSING
 GATE LEAF NO. 4 IN PLACE
 POOL ELEV 50.0 FT MSL
 TAILWATER ELEV 40.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

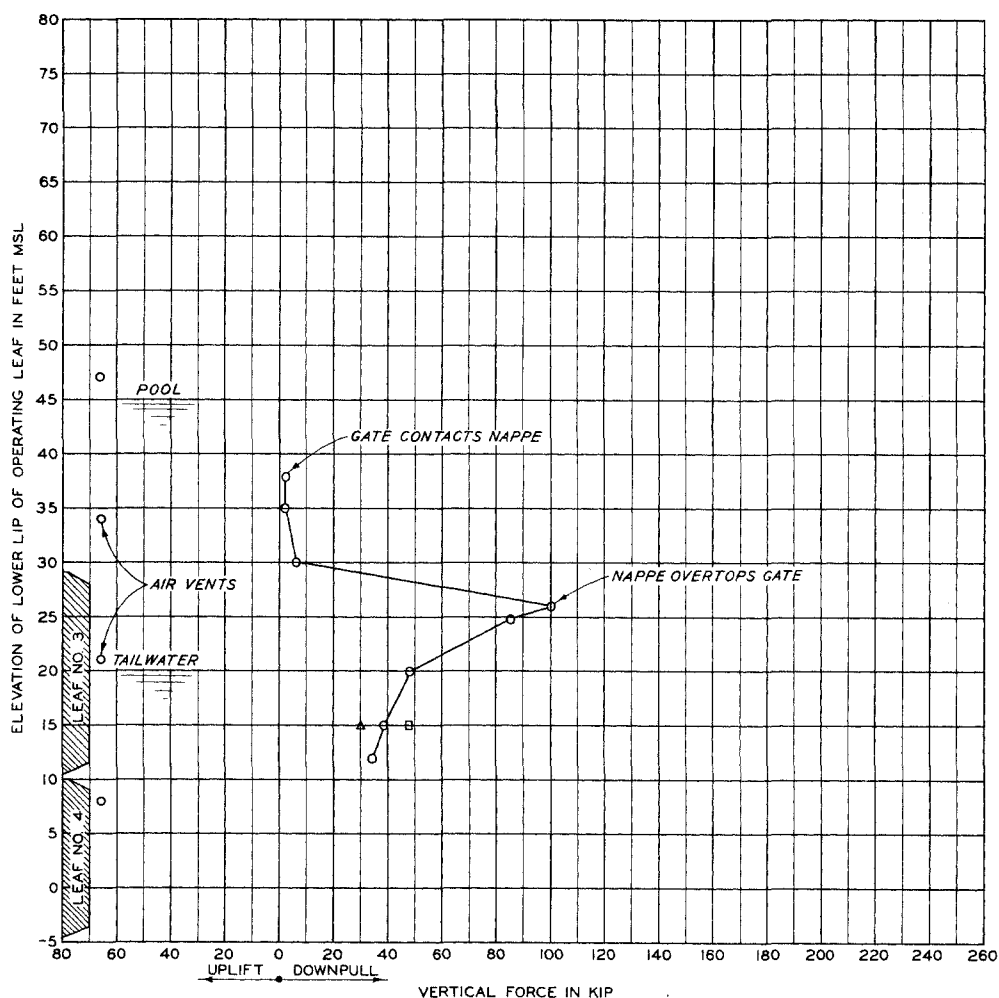
VERTICAL FORCES PLOTTED ARE EXTERNAL FORCES ACTING UPON THE GATE AS A RESULT OF FLOW OVER AND UNDER IT. IN ORDER TO OBTAIN THE TOTAL HOIST LOAD, THE DRY WEIGHT OF THE GATE SHOULD BE APPLIED TO THE FORCES SHOWN.

ALL BAYS CLOSED EXCEPT CENTER BAY (BAY NO. 6).

LEGEND
 ○ OBSERVED AVERAGE
 □ MAXIMUM
 △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 CLOSING
 GATE LEAF NO. 4 IN PLACE
 POOL ELEV 45.0 FT MSL
 TAILWATER ELEV 40.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

VERTICAL FORCES PLOTTED ARE EXTERNAL FORCES ACTING UPON THE GATE AS A RESULT OF FLOW OVER AND UNDER IT. IN ORDER TO OBTAIN THE TOTAL HOIST LOAD, THE DRY WEIGHT OF THE GATE SHOULD BE APPLIED TO THE FORCES SHOWN.

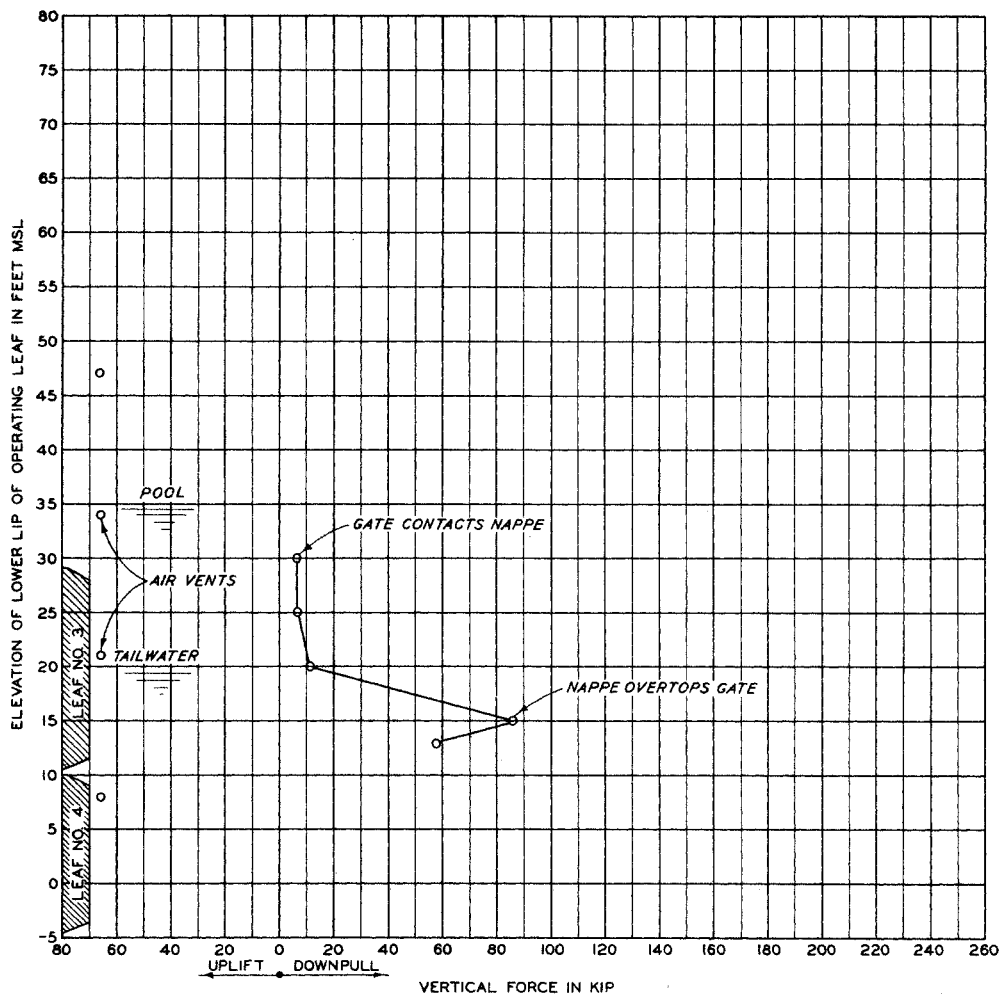
ALL BAYS CLOSED EXCEPT CENTER BAY (BAY NO. 6).

LEGEND

- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 CLOSING
GATE LEAF NO. 4 IN PLACE
POOL ELEV 45.0 FT MSL
TAILWATER ELEV 20.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

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ALL BAYS CLOSED EXCEPT CENTER BAY (BAY NO. 6).

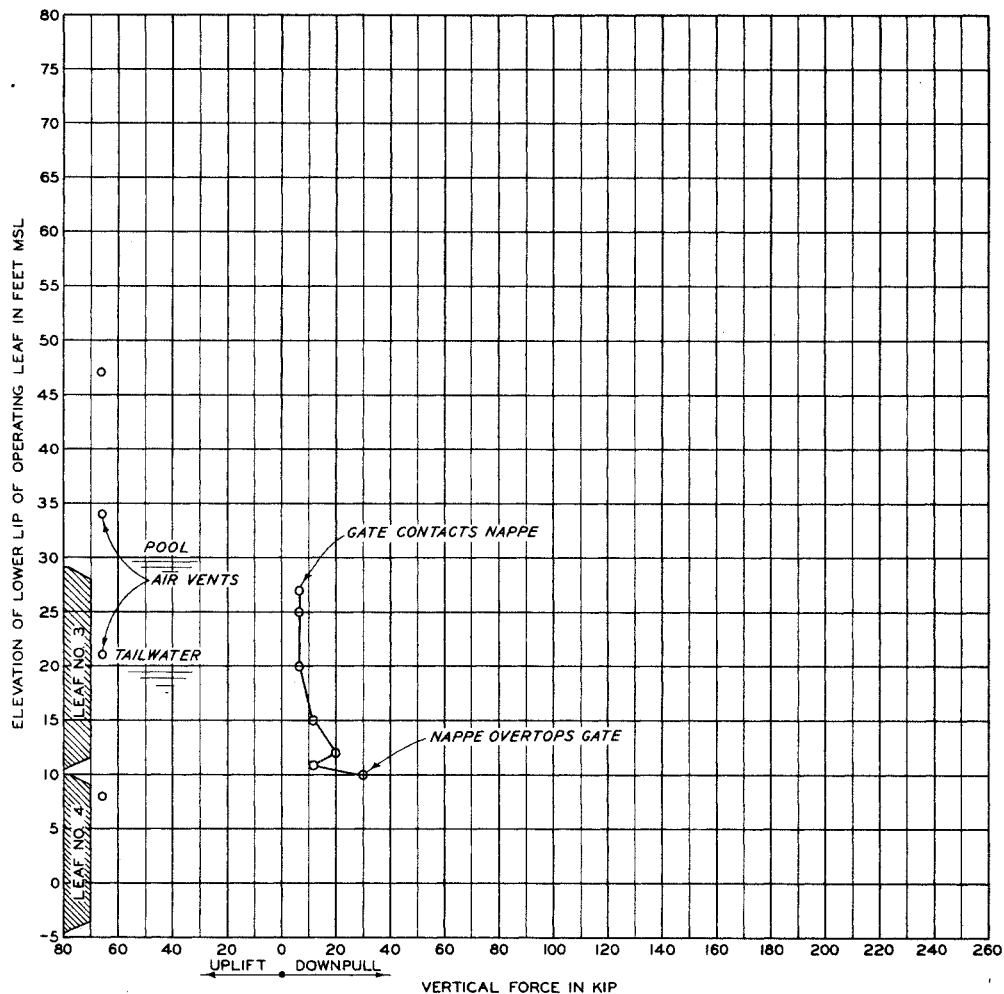
LEGEND

- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 CLOSING
GATE LEAF NO. 4 IN PLACE

POOL ELEV 35.0 FT MSL
TAILWATER ELEV 20.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

VERTICAL FORCES PLOTTED ARE EXTERNAL FORCES ACTING UPON THE GATE AS A RESULT OF FLOW OVER AND UNDER IT. IN ORDER TO OBTAIN THE TOTAL HOIST LOAD, THE DRY WEIGHT OF THE GATE SHOULD BE APPLIED TO THE FORCES SHOWN.

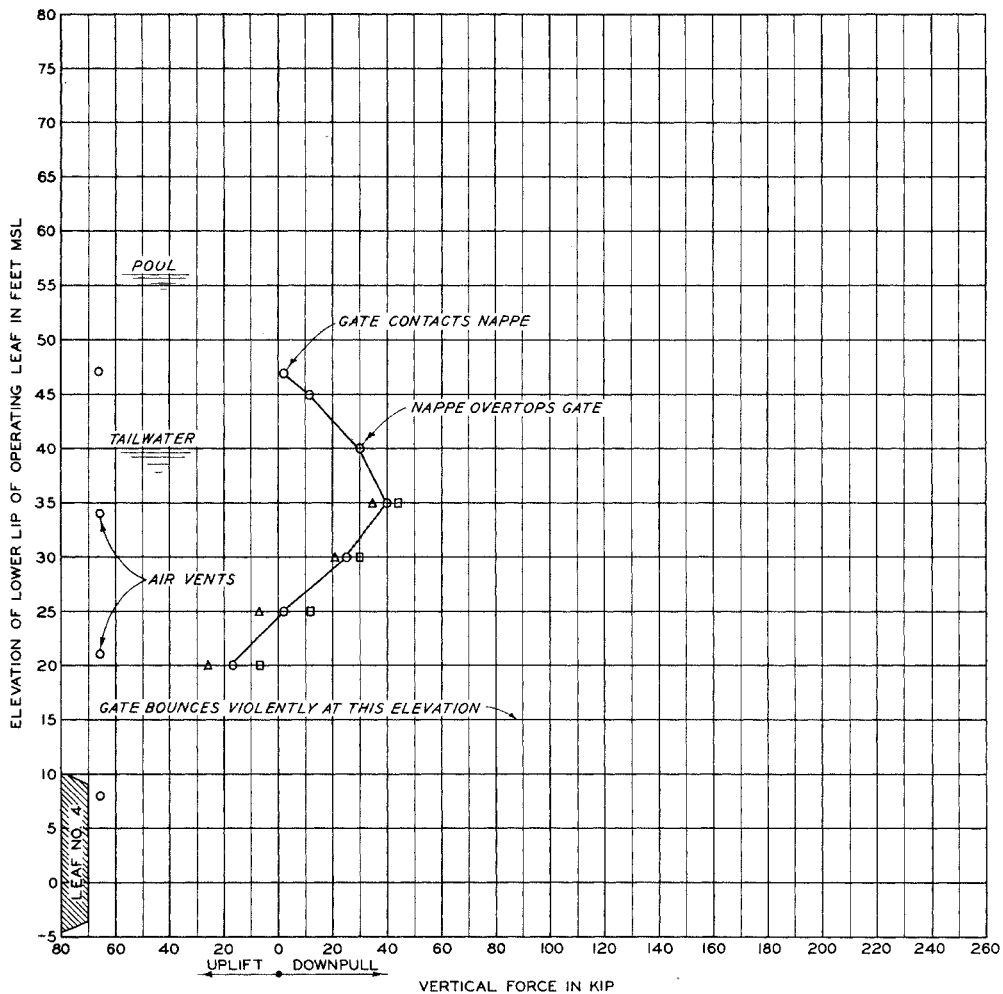
ALL BAYS CLOSED EXCEPT CENTER BAY (BAY NO. 6).

LEGEND

- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 CLOSING
GATE LEAF NO. 4 IN PLACE
POOL ELEV. 30.0 FT MSL
TAILWATER ELEV. 20.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

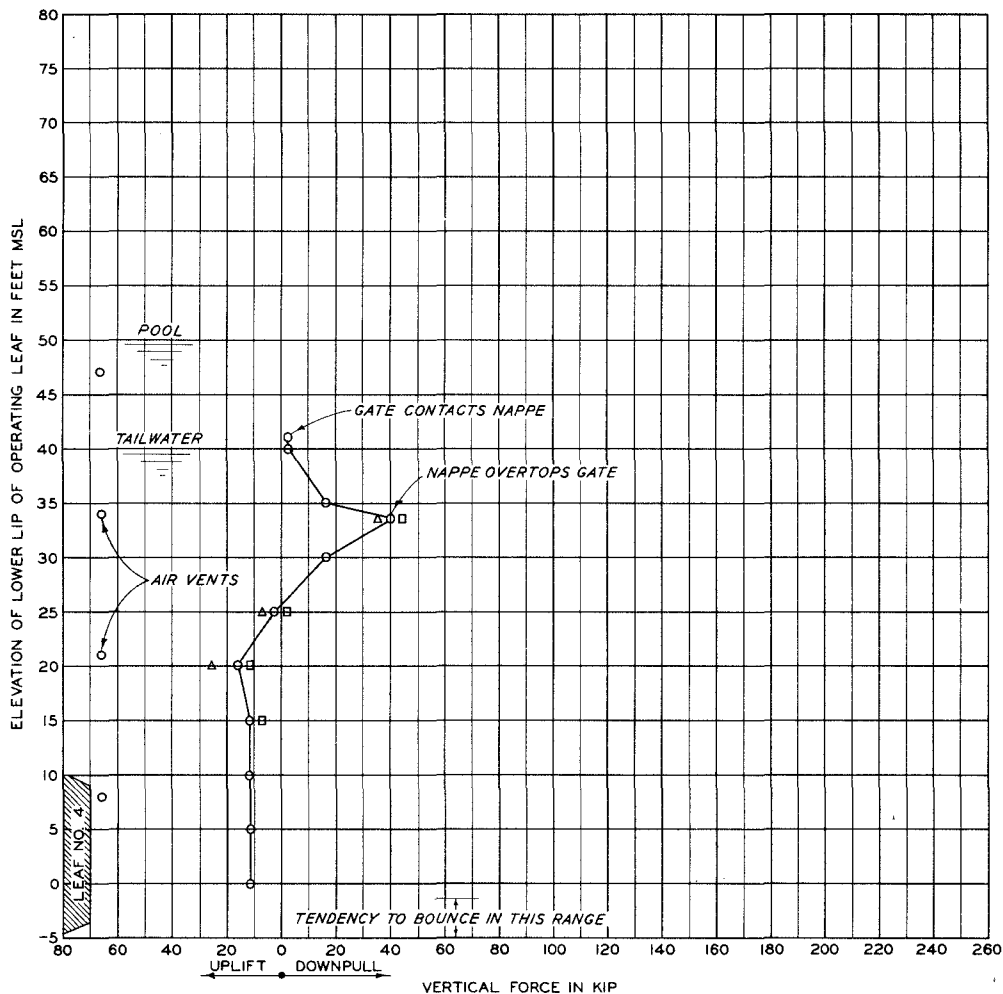
VERTICAL FORCES PLOTTED ARE EXTERNAL FORCES ACTING UPON THE GATE AS A RESULT OF FLOW OVER AND UNDER IT. IN ORDER TO OBTAIN THE TOTAL HOIST LOAD, THE DRY WEIGHT OF THE GATE SHOULD BE APPLIED TO THE FORCES SHOWN.

ALL BAYS CLOSED EXCEPT CENTER BAY (BAY NO. 6).

LEGEND
 O OBSERVED AVERAGE
 □ MAXIMUM
 △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF GATE LEAF NO. 4 CLOSING

POOL ELEV 56.0 FT MSL
 TAILWATER ELEV 40.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

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ALL BAYS CLOSED EXCEPT CENTER BAY (BAY NO. 6).

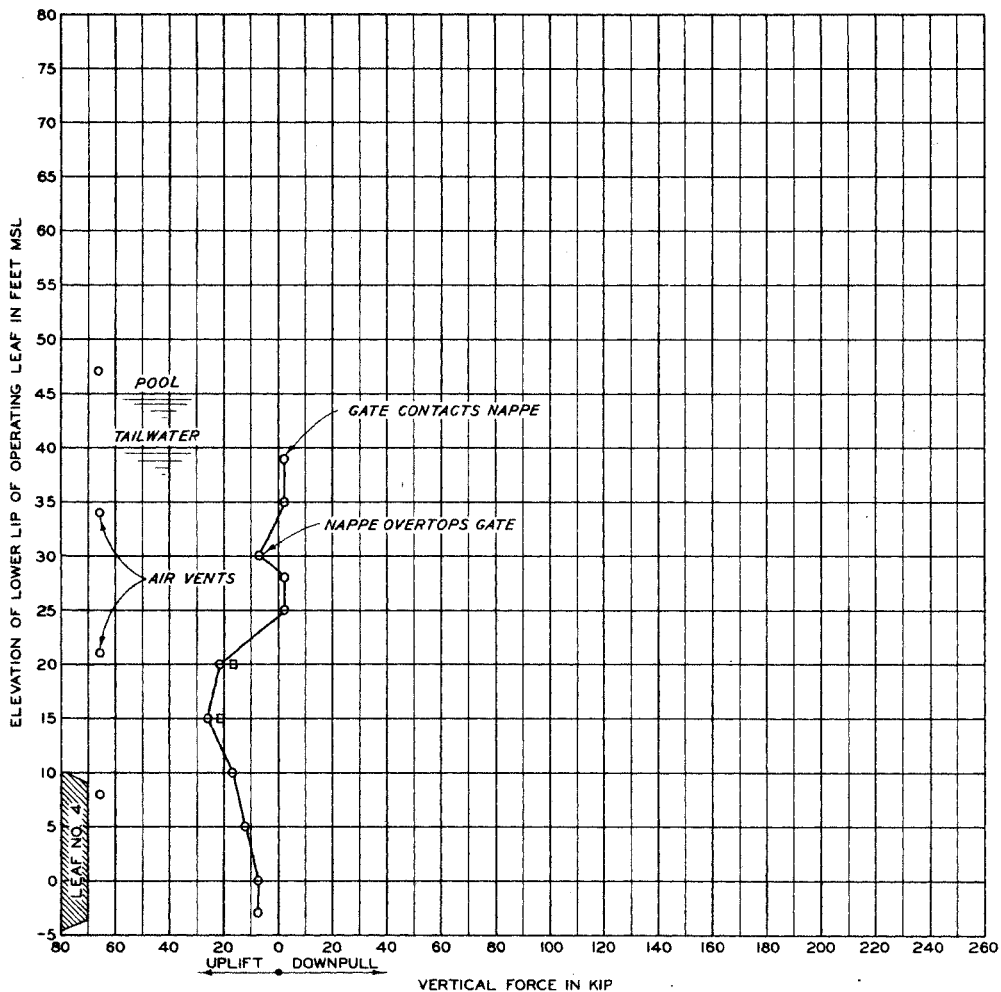
LEGEND

- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 4 CLOSING

POOL ELEV 50.0 FT MSL
TAILWATER ELEV 40.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

VERTICAL FORCES PLOTTED ARE EXTERNAL FORCES ACTING UPON THE GATE AS A RESULT OF FLOW OVER AND UNDER IT. IN ORDER TO OBTAIN THE TOTAL HOIST LOAD, THE DRY WEIGHT OF THE GATE SHOULD BE APPLIED TO THE FORCES SHOWN.

ALL BAYS CLOSED EXCEPT CENTER BAY (BAY NO. 6).

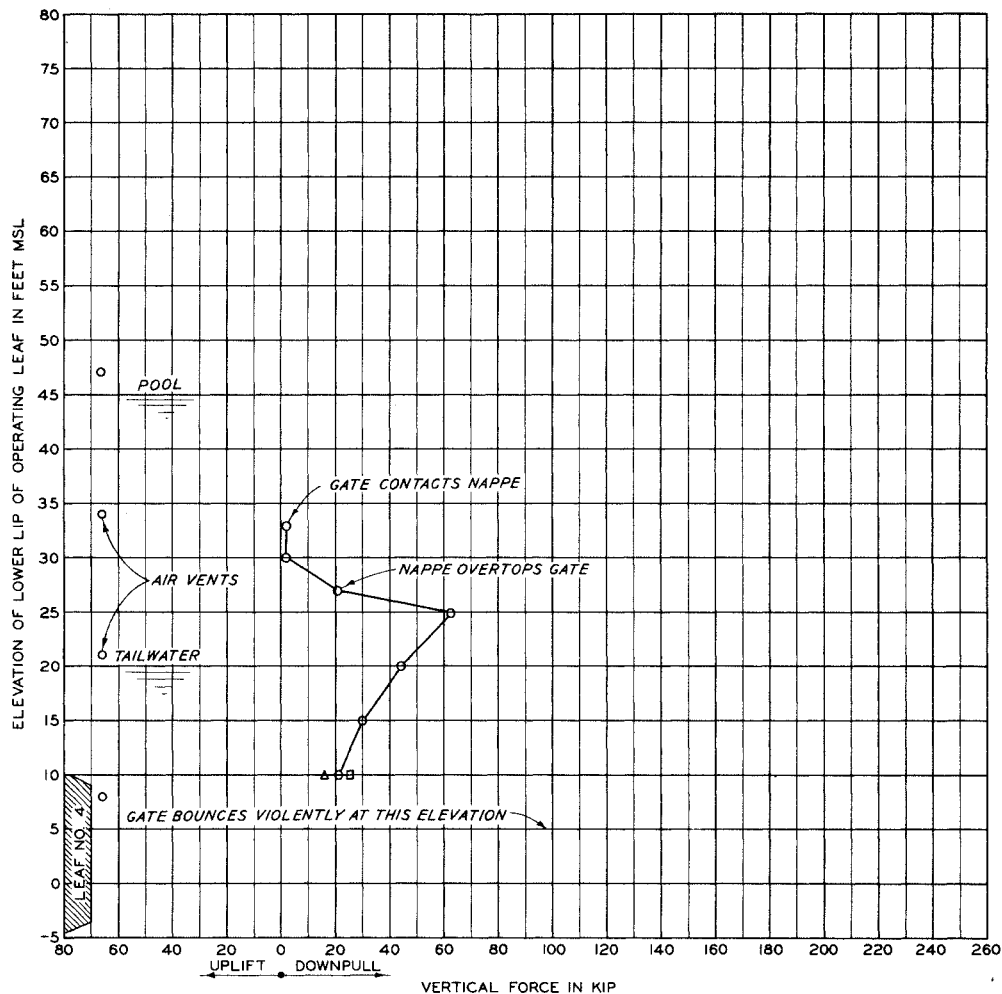
LEGEND

- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 4 CLOSING

POOL ELEV 45.0 FT MSL
TAILWATER ELEV 40.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

VERTICAL FORCES PLOTTED ARE EXTERNAL FORCES ACTING UPON THE GATE AS A RESULT OF FLOW OVER AND UNDER IT. IN ORDER TO OBTAIN THE TOTAL HOIST LOAD, THE DRY WEIGHT OF THE GATE SHOULD BE APPLIED TO THE FORCES SHOWN.

ALL BAYS CLOSED EXCEPT CENTER BAY (BAY NO. 6).

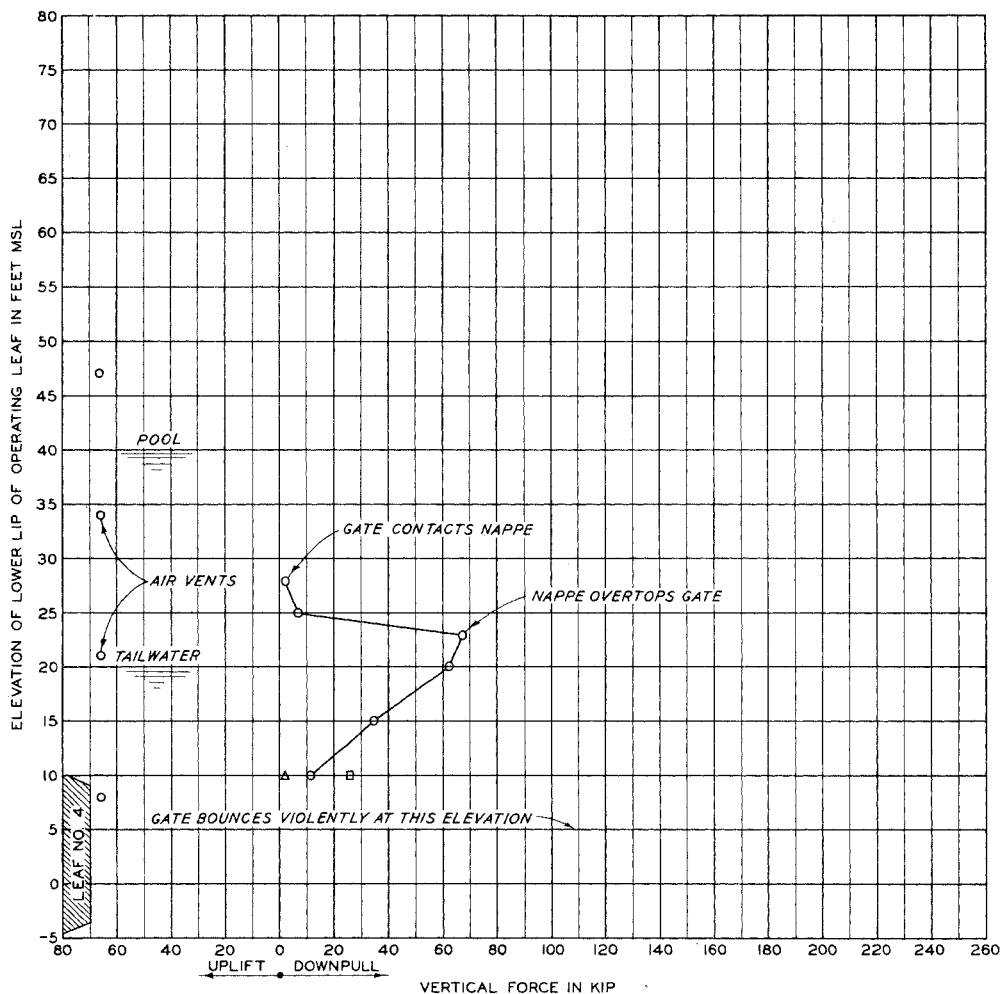
LEGEND

- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 4 CLOSING

POOL ELEV 45.0 FT MSL
TAILWATER ELEV 20.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

VERTICAL FORCES PLOTTED ARE EXTERNAL FORCES ACTING UPON THE GATE AS A RESULT OF FLOW OVER AND UNDER IT. IN ORDER TO OBTAIN THE TOTAL HOIST LOAD, THE DRY WEIGHT OF THE GATE SHOULD BE APPLIED TO THE FORCES SHOWN.

ALL BAYS CLOSED EXCEPT CENTER BAY (BAY NO. 6).

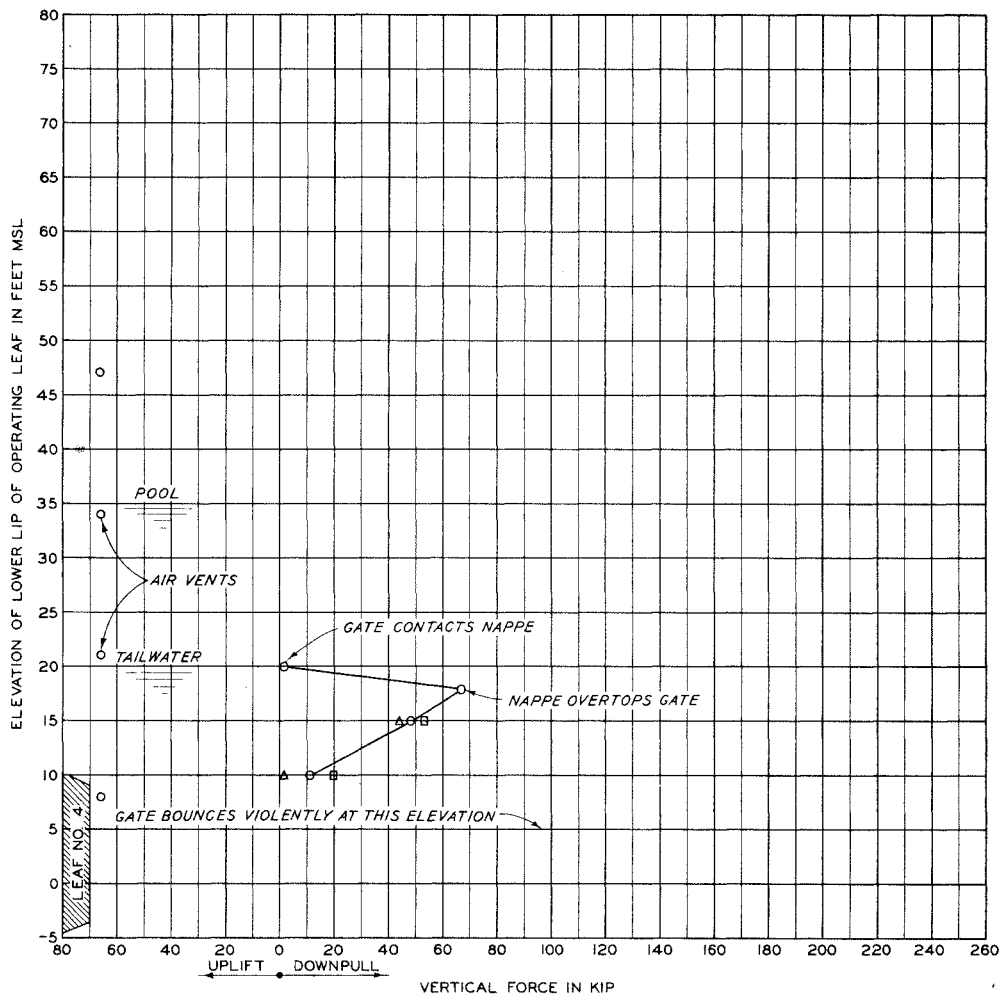
LEGEND

- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 4 CLOSING

POOL ELEV 40.0 FT MSL
TAILWATER ELEV 20.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

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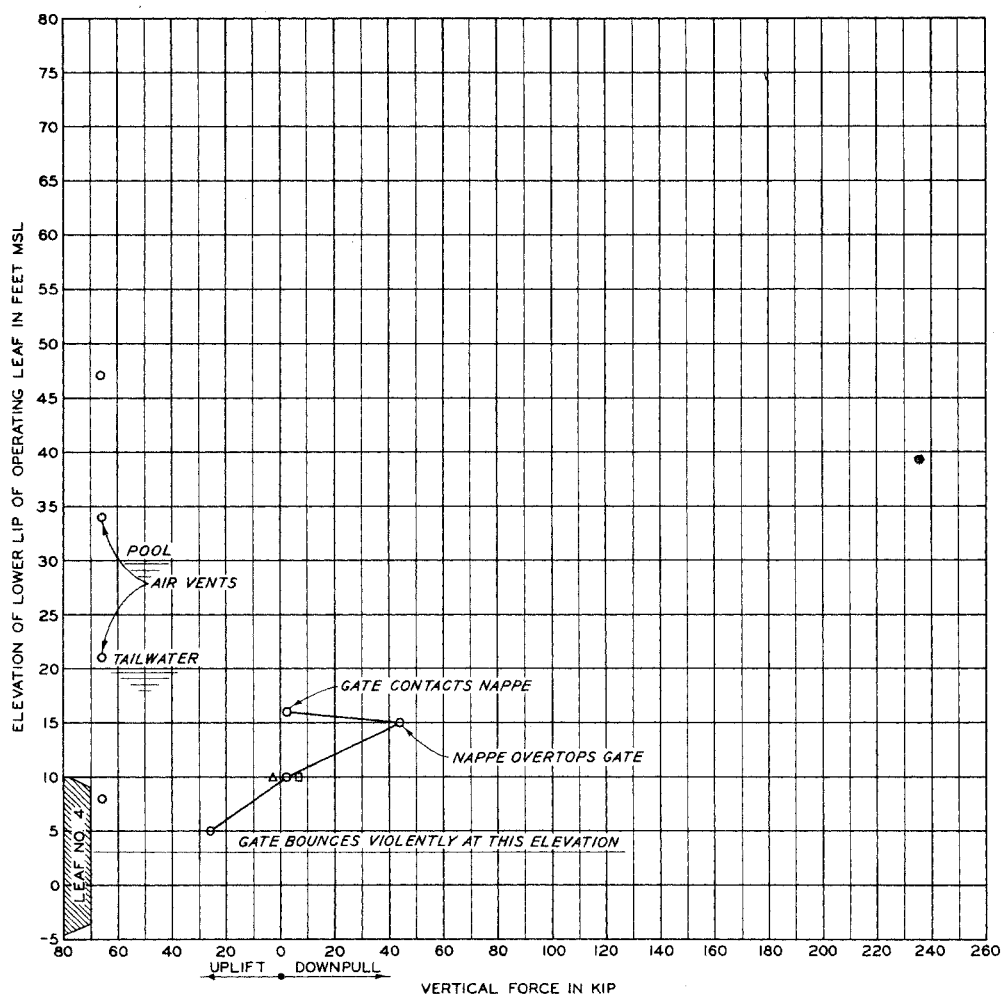
LEGEND

- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 4 CLOSING

POOL ELEV 35.0 FT MSL
TAILWATER ELEV 20.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

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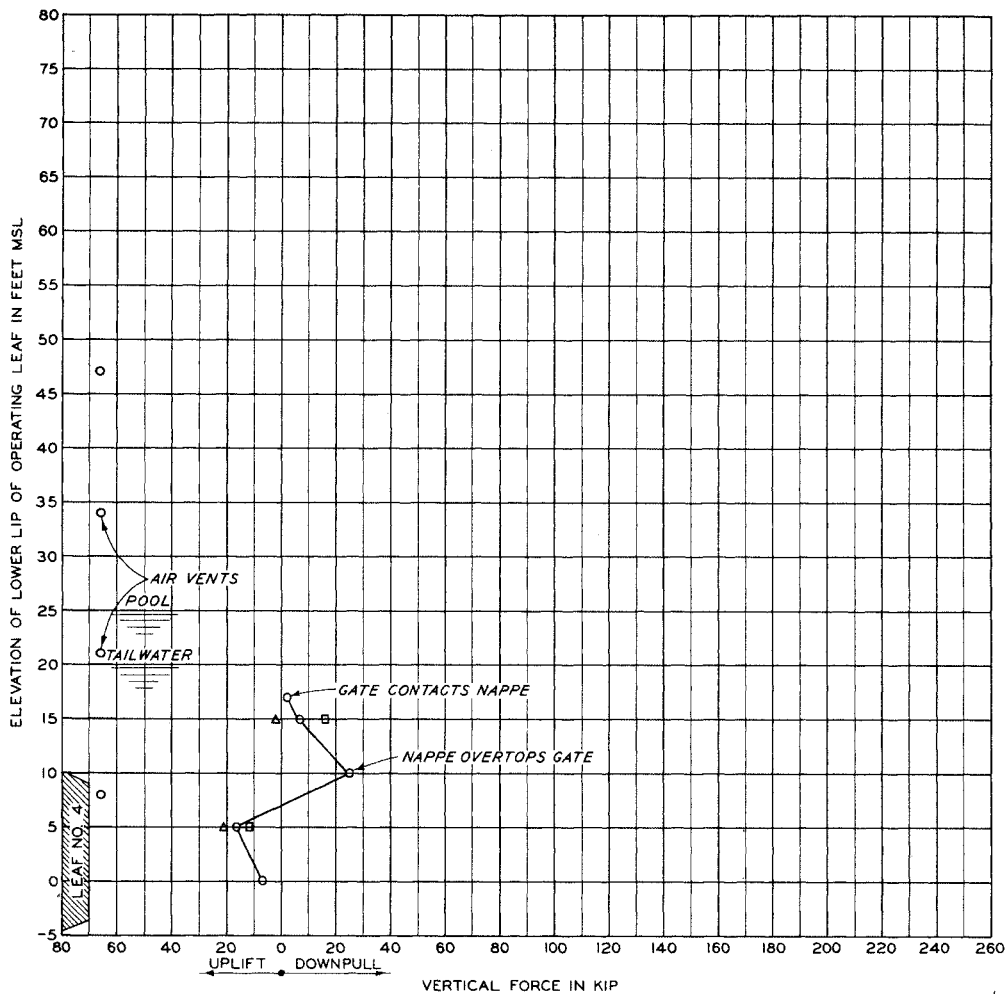
LEGEND

- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 4 CLOSING

POOL ELEV 30.0 FT MSL
TAILWATER ELEV 20.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

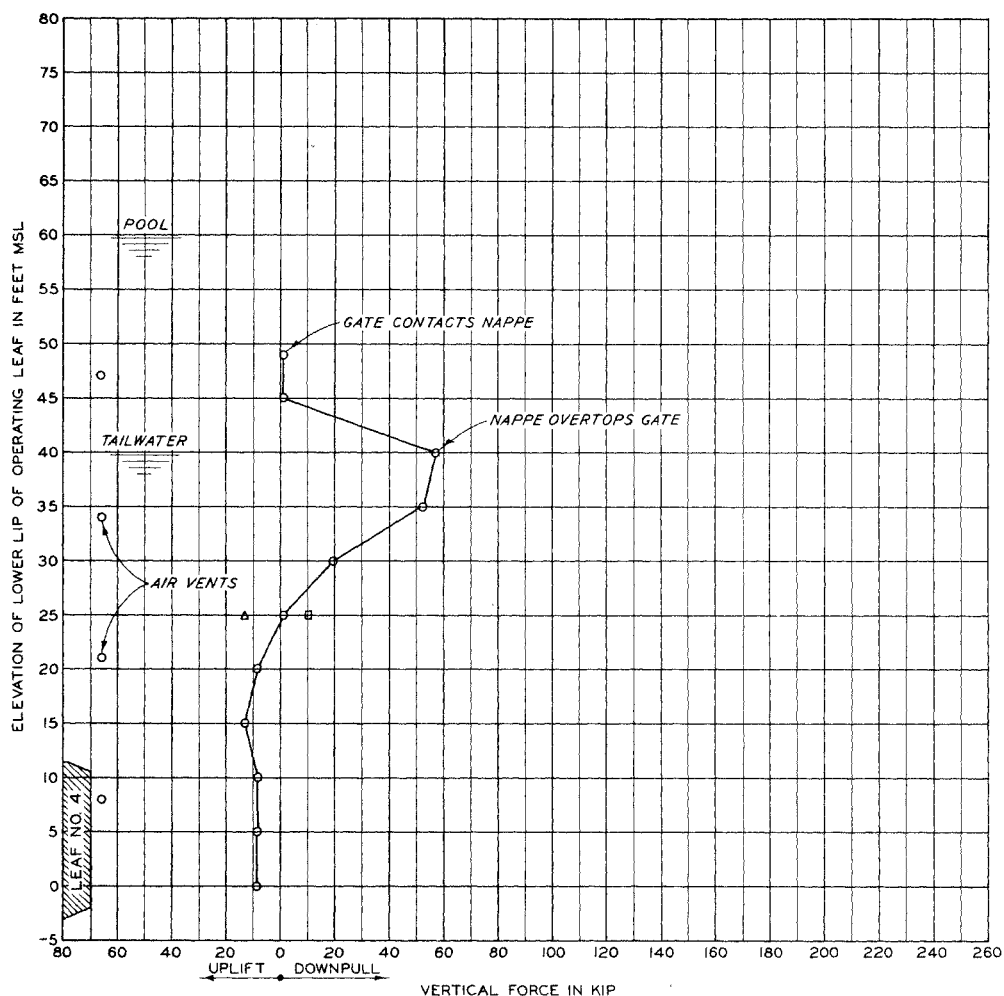
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LEGEND
 O OBSERVED AVERAGE
 □ MAXIMUM
 △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF GATE LEAF NO. 4 CLOSING

POOL ELEV 25.0 FT MSL
 TAILWATER ELEV 20.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

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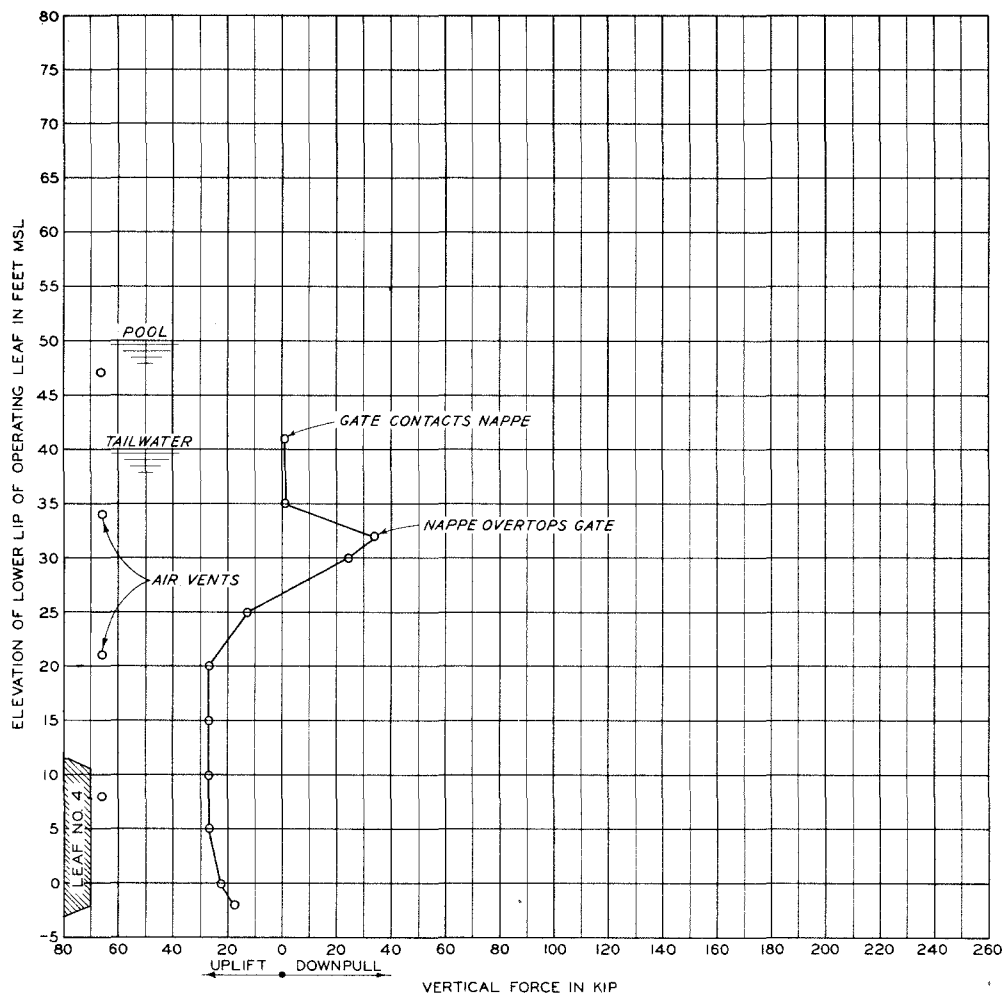
ALL BAYS CLOSED EXCEPT CENTER BAY (BAY NO. 6).

LEGEND

- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I-A GATE LEAF GATE LEAF NO. 4 CLOSING

POOL ELEV 60.0 FT MSL
TAILWATER ELEV 40.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

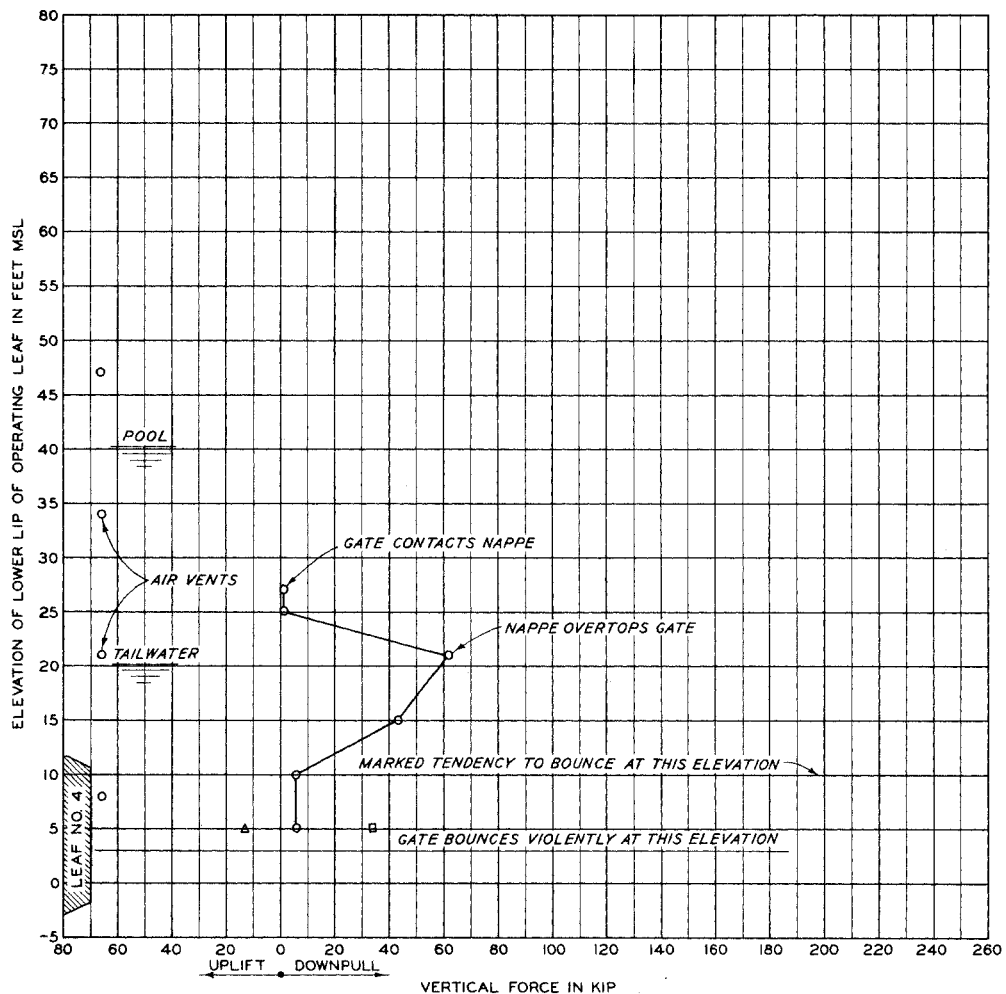
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LEGEND
 O OBSERVED AVERAGE
 □ MAXIMUM
 Δ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I-A GATE LEAF GATE LEAF NO. 4 CLOSING

POOL ELEV 50.0 FT MSL
 TAILWATER ELEV 40.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

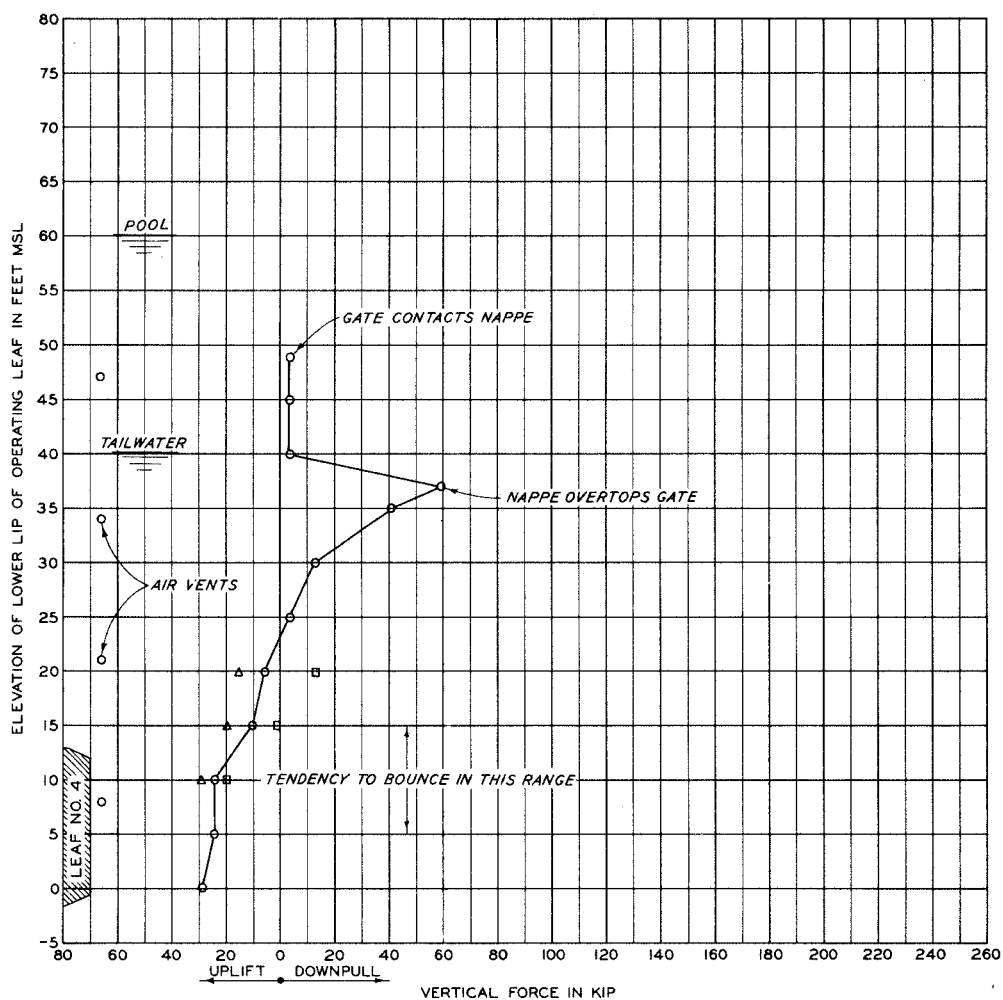
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LEGEND
 O OBSERVED AVERAGE
 □ MAXIMUM
 △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I-A GATE LEAF GATE LEAF NO. 4 CLOSING

POOL ELEV 40.0 FT MSL
 TAILWATER ELEV 20.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

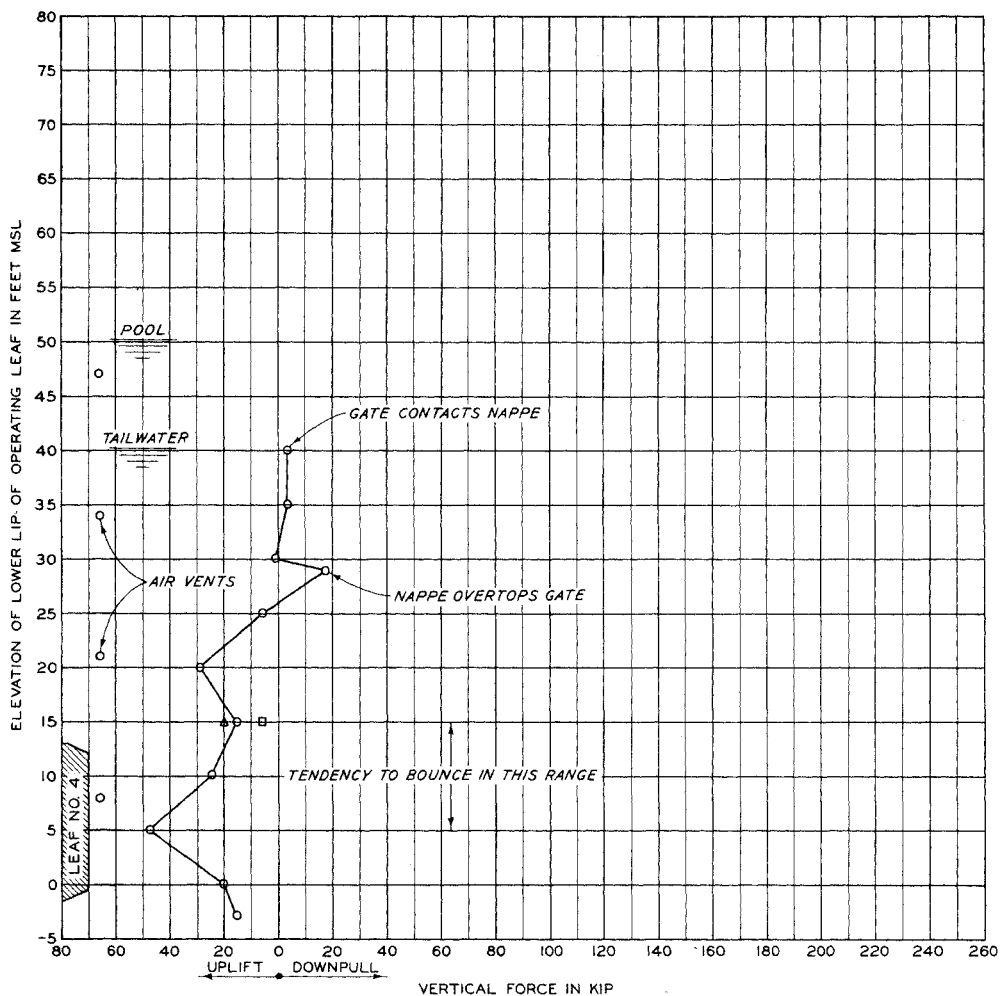
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LEGEND
 O OBSERVED AVERAGE
 □ MAXIMUM
 Δ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I-B GATE LEAF GATE LEAF NO. 4 CLOSING

POOL ELEV 60.0 FT MSL
 TAILWATER ELEV 40.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

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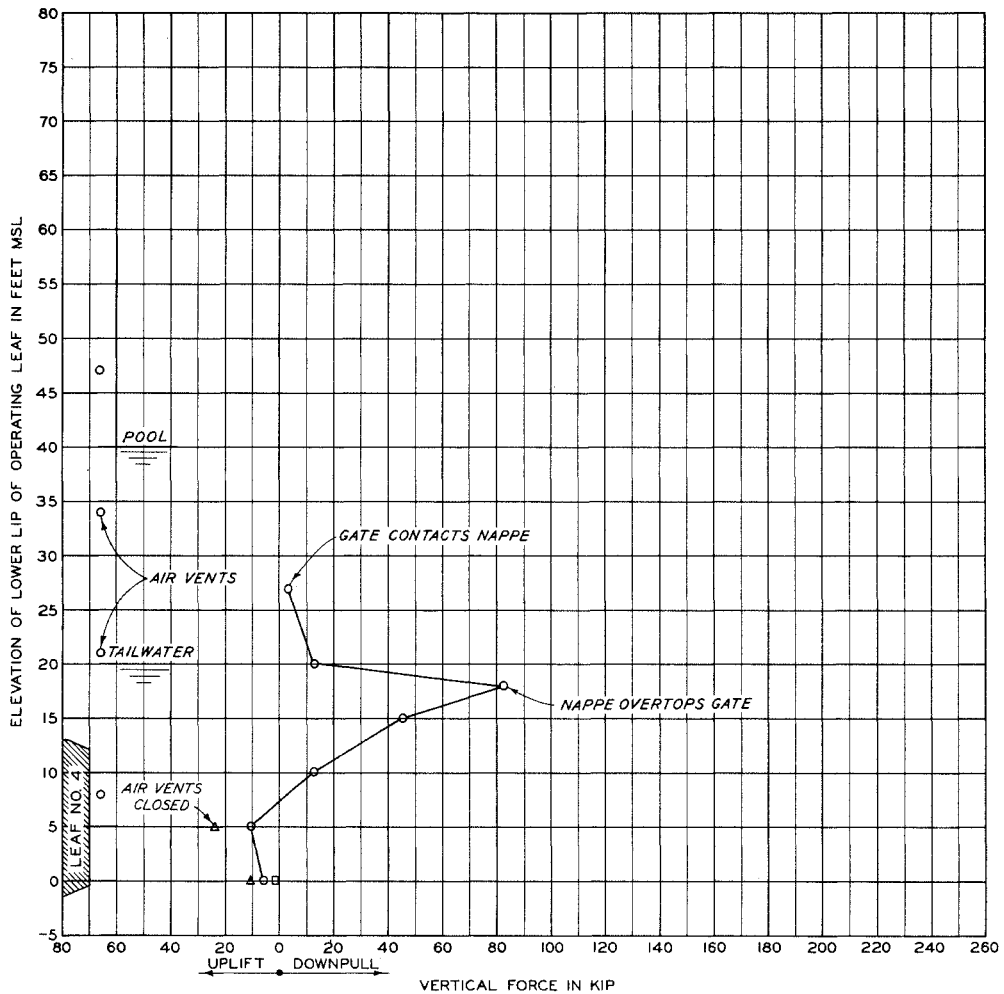
LEGEND

- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I-B GATE LEAF

GATE LEAF NO. 4 CLOSING

POOL ELEV 50.0 FT MSL
TAILWATER ELEV 40.0 FT MSL



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LEGEND

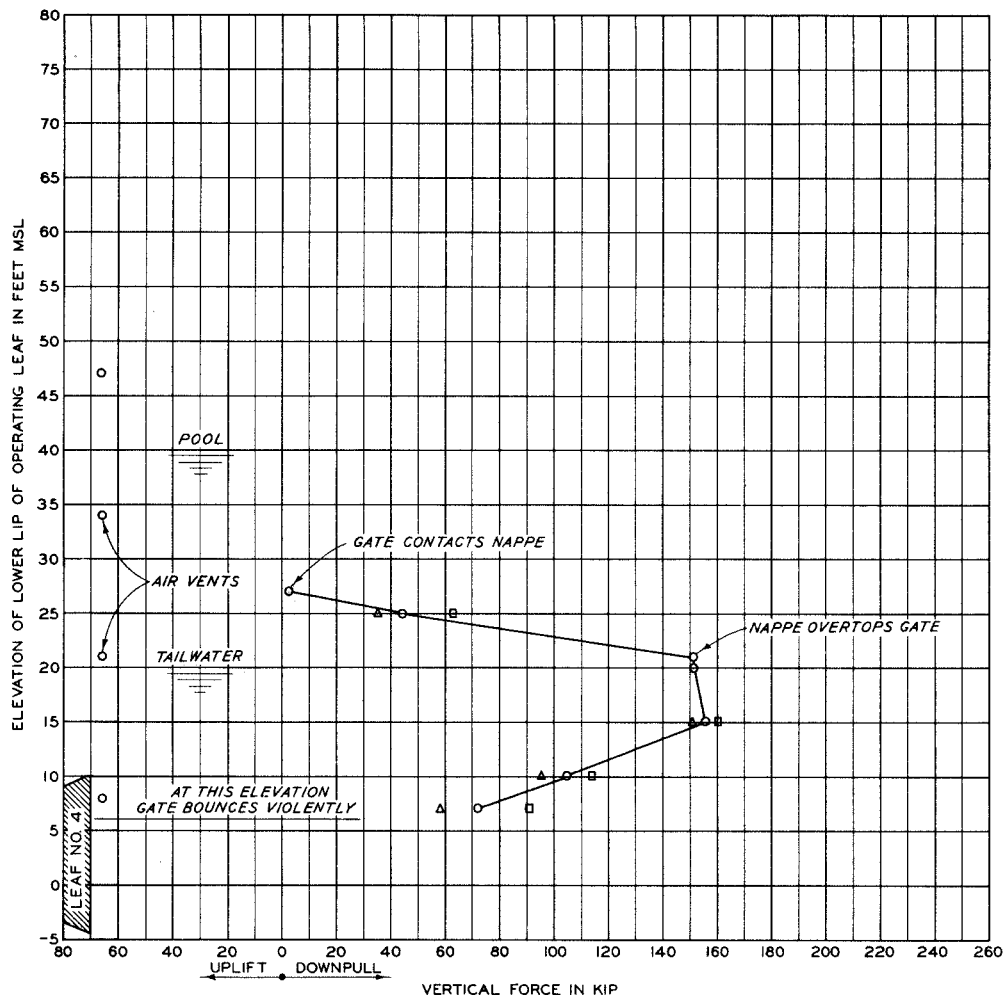
- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE

TYPE I-B GATE LEAF

GATE LEAF NO. 4 CLOSING

POOL ELEV 40.0 FT MSL
TAILWATER ELEV 20.0 FT MSL



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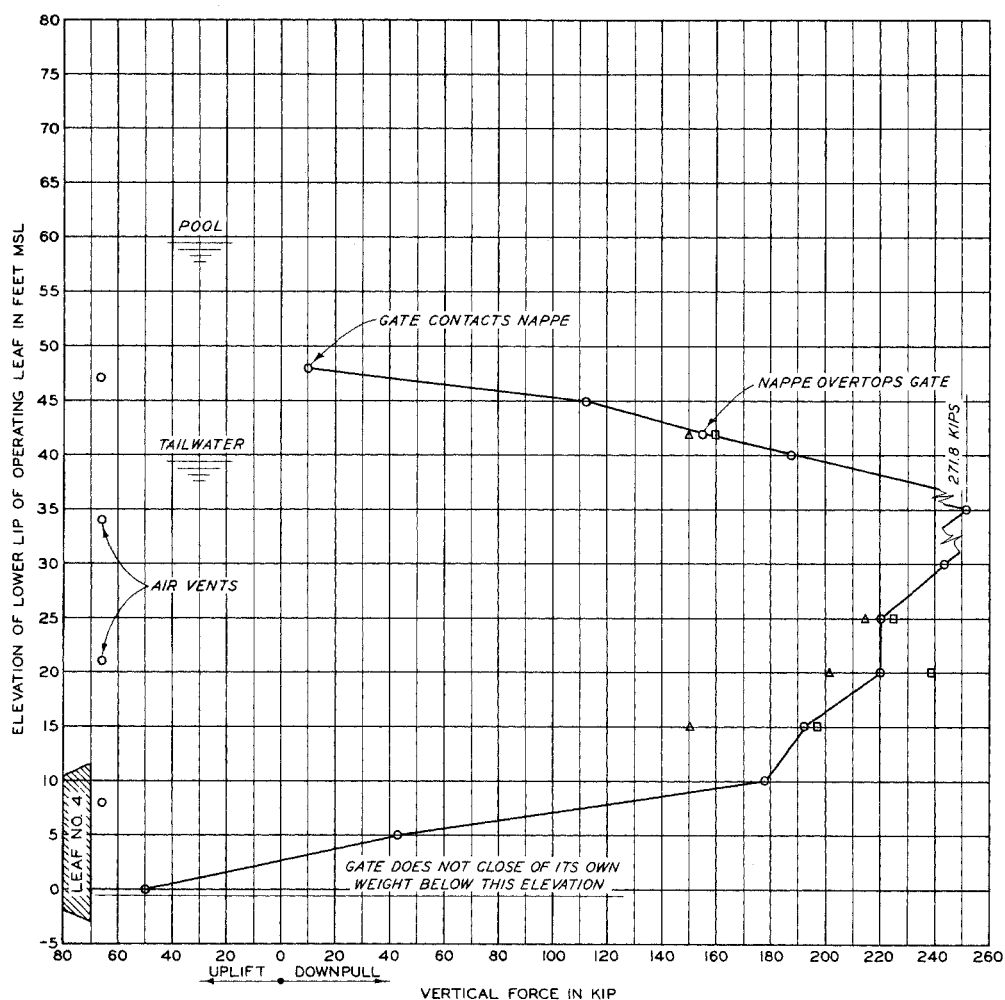
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LEGEND

- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I-R GATE LEAF GATE LEAF NO. 4 CLOSING

POOL ELEV 40.0 FT MSL
TAILWATER ELEV 20.0 FT MSL



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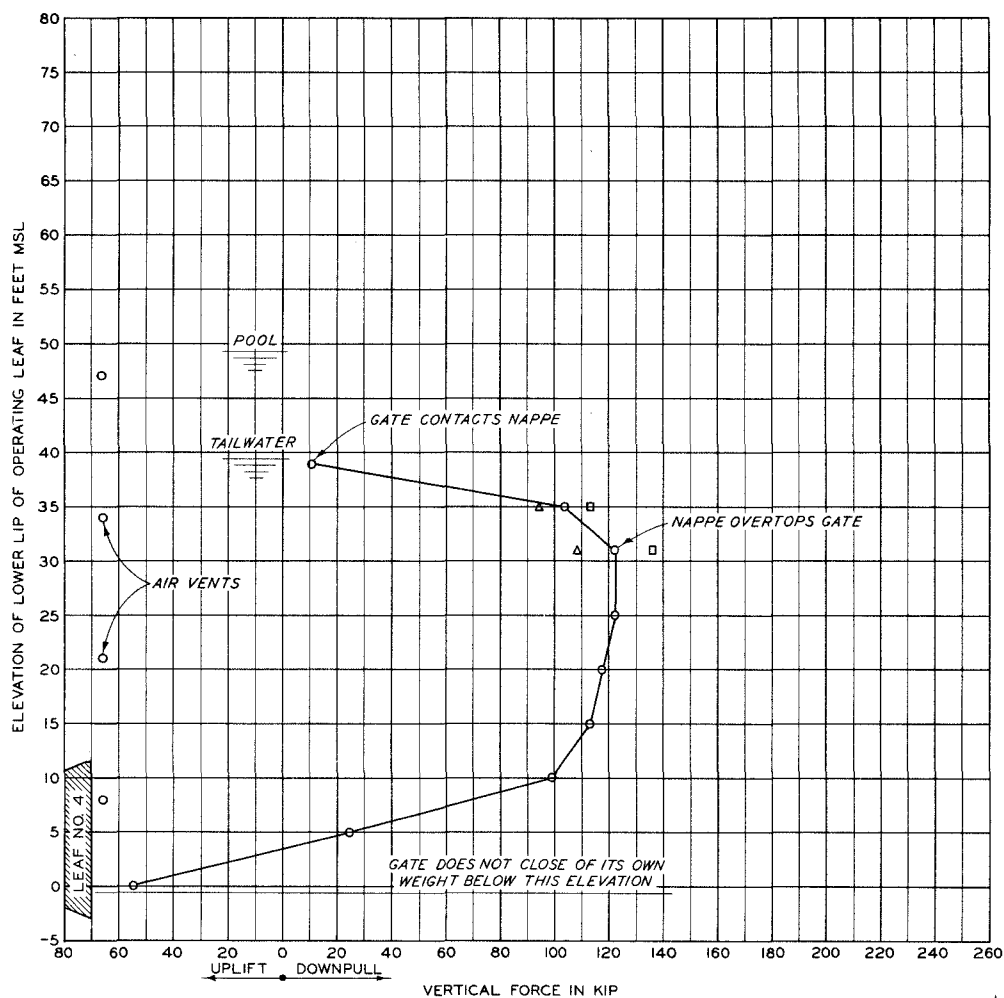
LEGEND

- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I-A-R GATE LEAF

GATE LEAF NO. 4 CLOSING

POOL ELEV 60.0 FT MSL
TAILWATER ELEV 40.0 FT MSL



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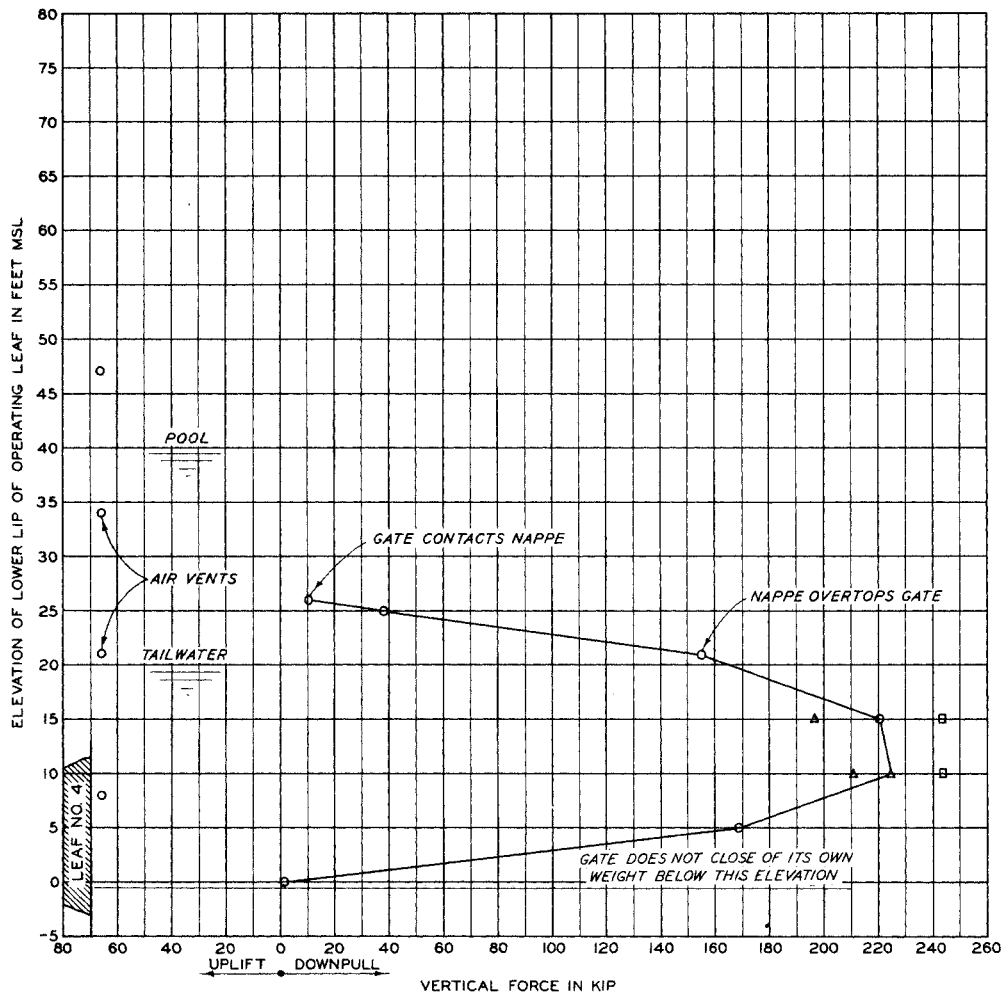
LEGEND

- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I-A-R GATE LEAF

GATE LEAF NO. 4 CLOSING

POOL ELEV 50.0 FT MSL
TAILWATER ELEV 40.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

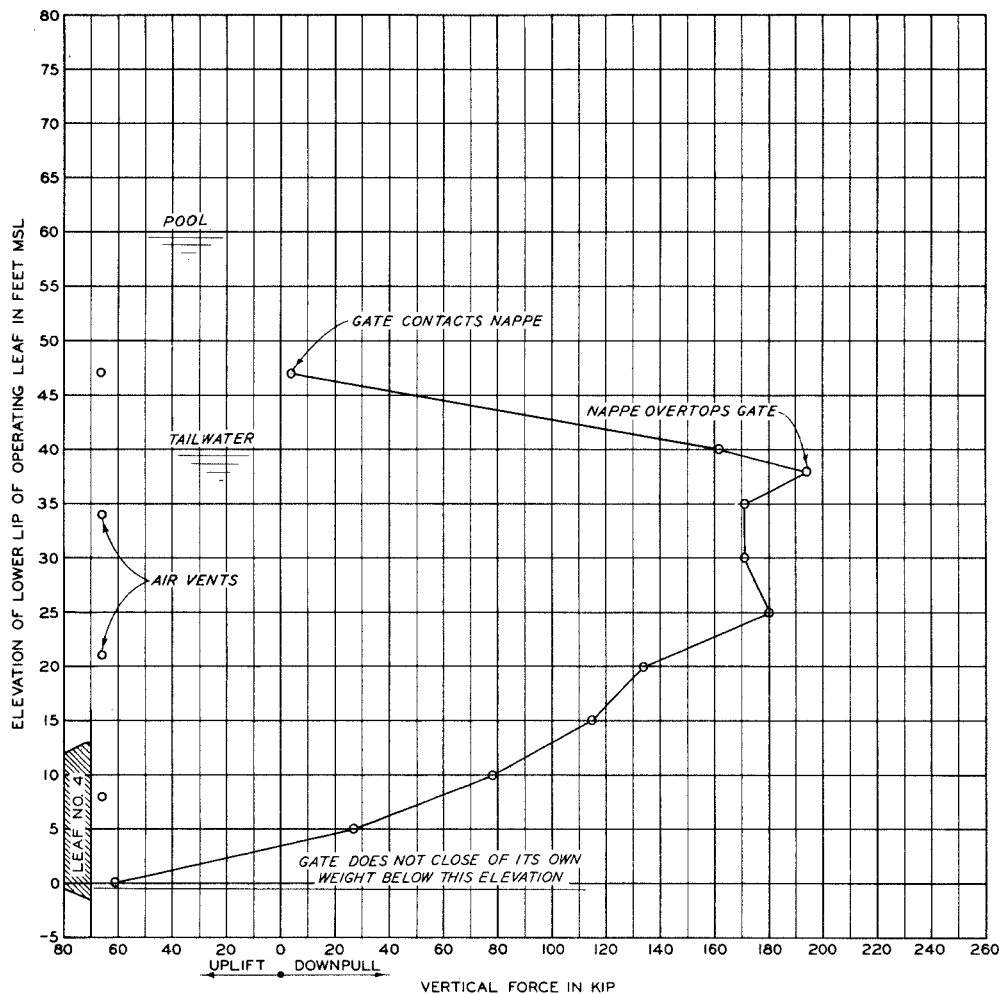
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LEGEND
 ○ OBSERVED AVERAGE
 □ MAXIMUM
 △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I-A-R GATE LEAF GATE LEAF NO. 4 CLOSING

POOL ELEV 40.0 FT MSL
 TAILWATER ELEV 20.0 FT MSL



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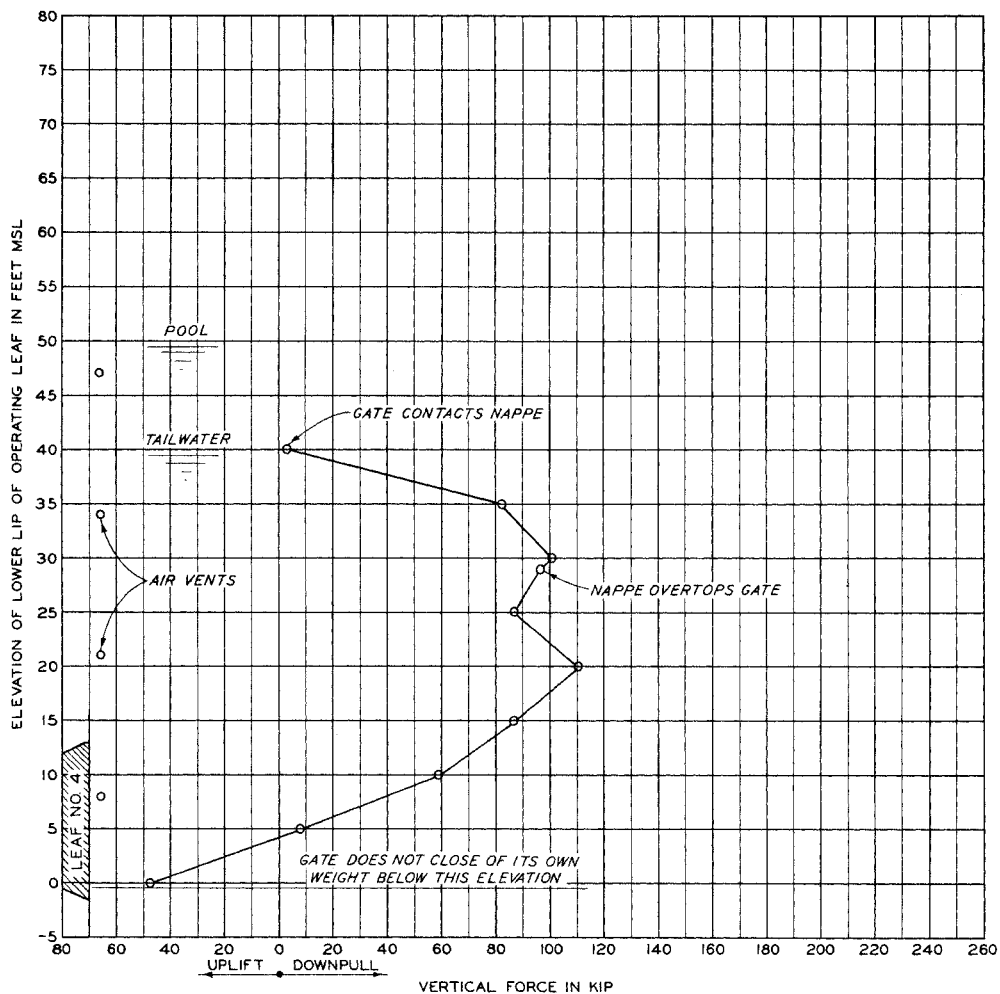
LEGEND

- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I-B-R GATE LEAF

GATE LEAF NO. 4 CLOSING

POOL ELEV 600 FT MSL
TAILWATER ELEV 400 FT MSL



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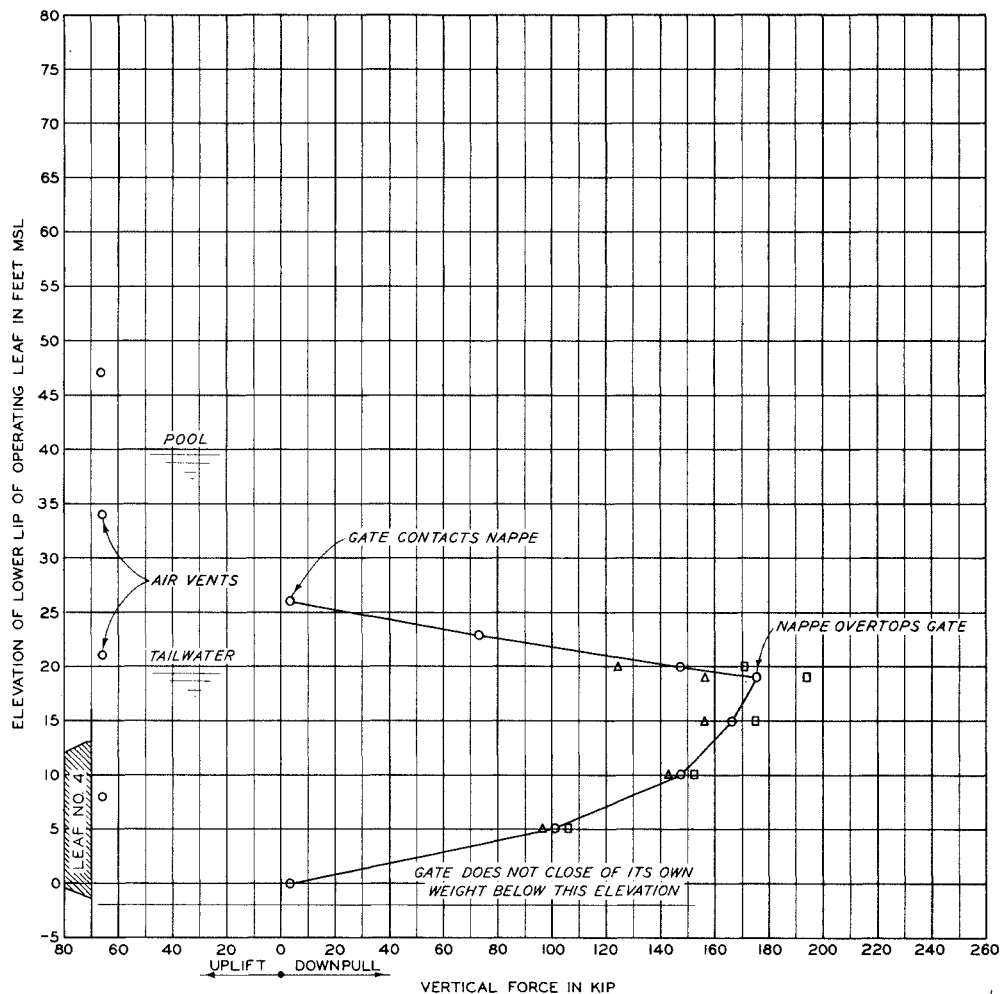
LEGEND

- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I-B-R GATE LEAF

GATE LEAF NO. 4 CLOSING

POOL ELEV 50.0 FT MSL
TAILWATER ELEV 40.0 FT MSL



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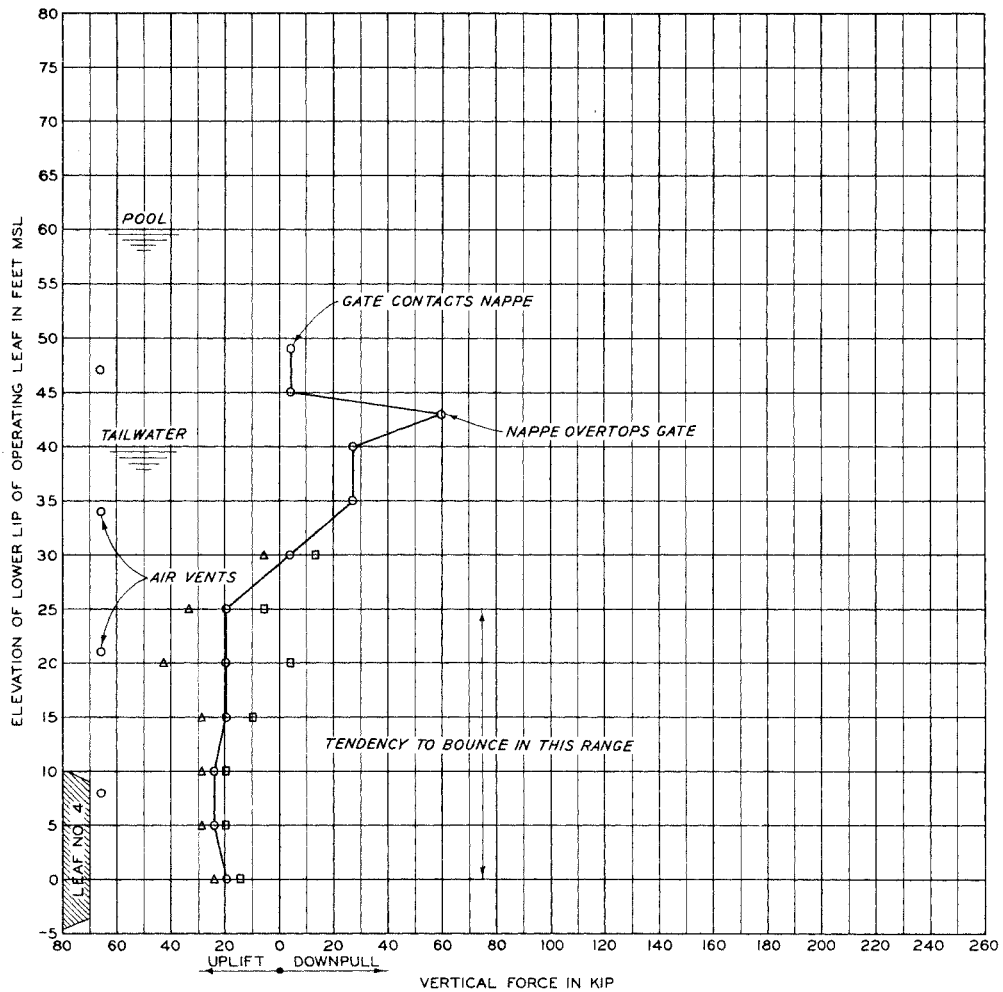
LEGEND

- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I-B-R GATE LEAF

GATE LEAF NO. 4 CLOSING

POOL ELEV 40.0 FT MSL
TAILWATER ELEV 20.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

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LEGEND

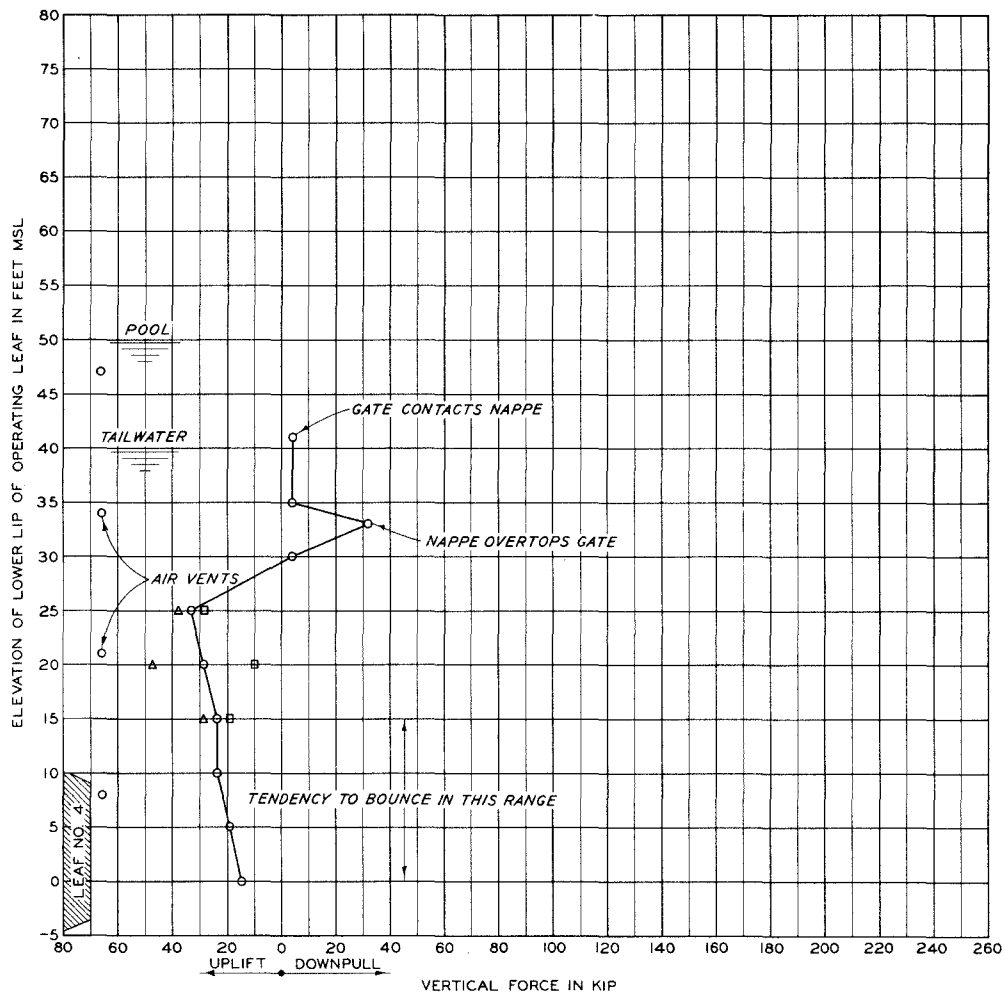
- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE

TYPE 2 GATE LEAF

GATE LEAF NO. 4 CLOSING

POOL ELEV 60.0 FT MSL
TAILWATER ELEV 40.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

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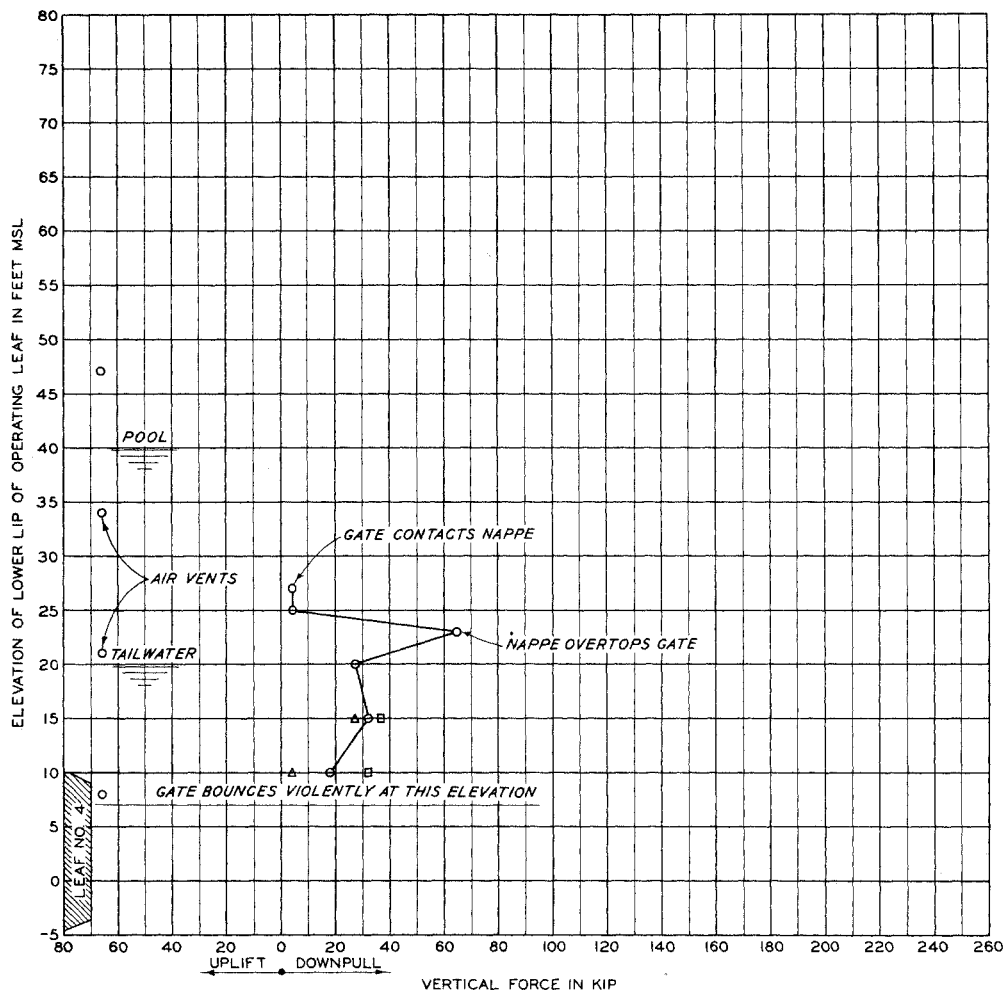
LEGEND

- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE 2 GATE LEAF

GATE LEAF NO. 4 CLOSING

POOL ELEV 50.0 FT MSL
TAILWATER ELEV 40.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

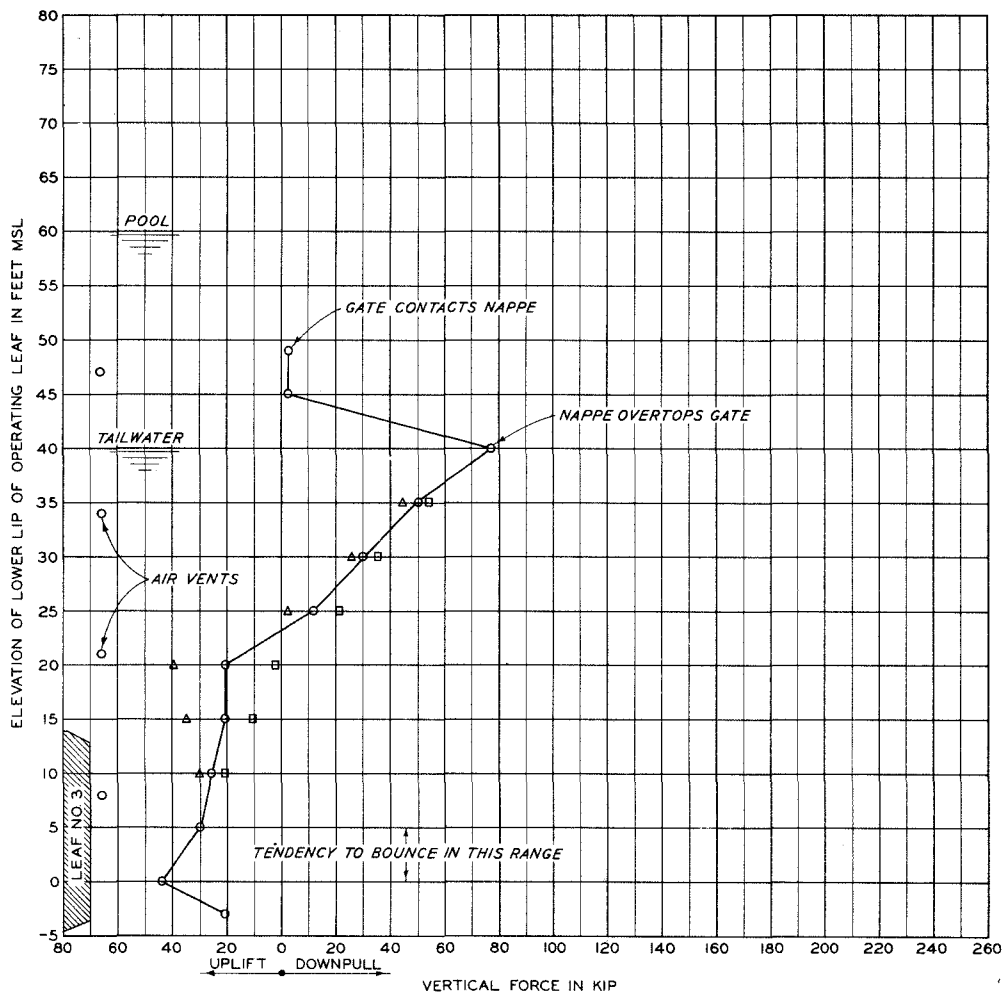
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ALL BAYS CLOSED EXCEPT CENTER BAY (BAY NO. 6).

LEGEND
 ○ OBSERVED AVERAGE
 □ MAXIMUM
 △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE 2 GATE LEAF GATE LEAF NO. 4 CLOSING

POOL ELEV 40.0 FT MSL
 TAILWATER ELEV 20.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

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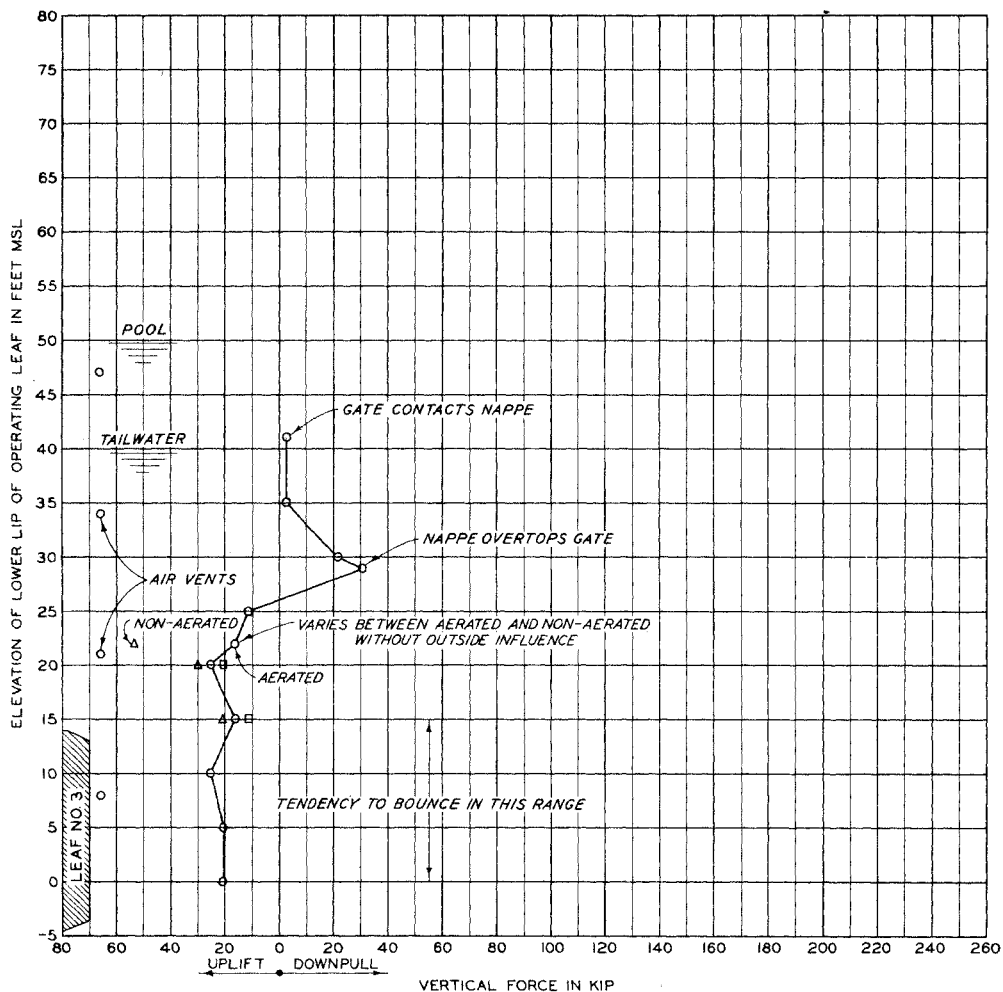
LEGEND

- OBSERVED AVERAGE
- MAXIMUM
- Δ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 CLOSING

POOL ELEV 60.0 FT MSL
TAILWATER ELEV 40.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

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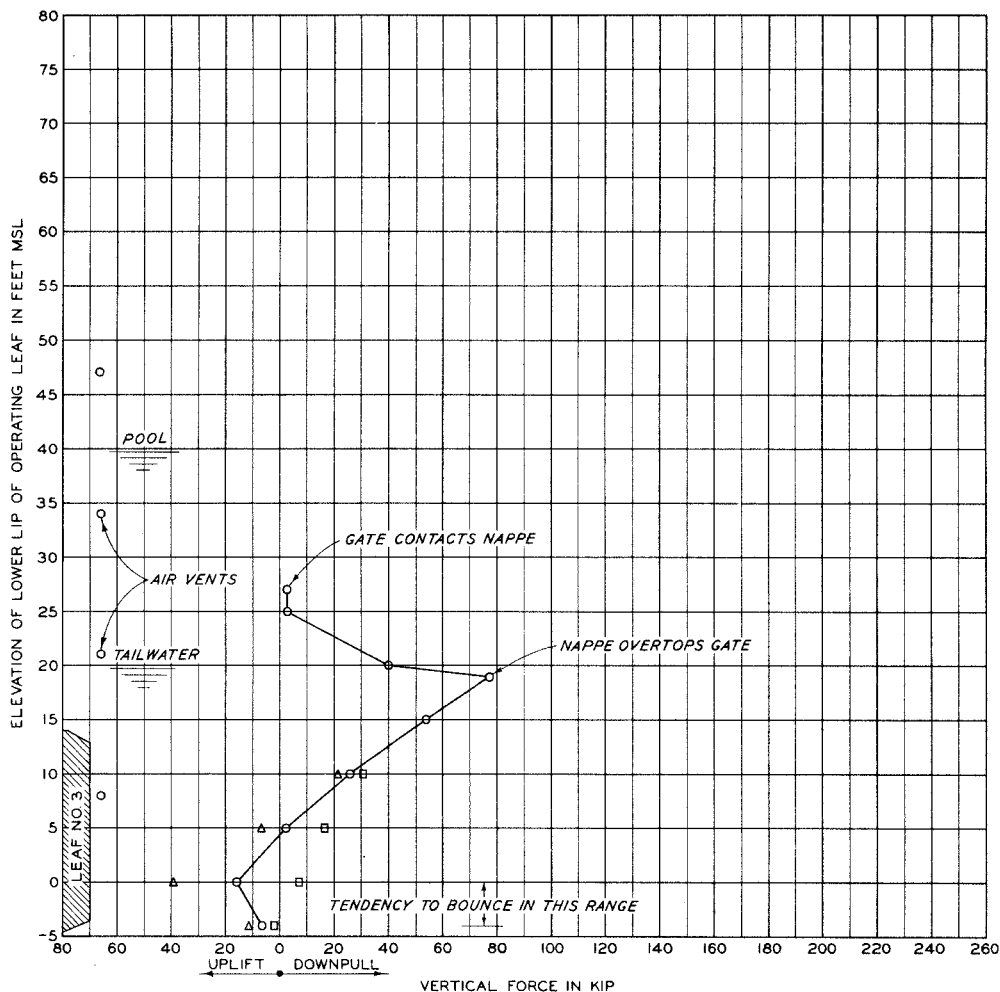
LEGEND

- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 CLOSING

POOL ELEV 50.0 FT MSL
TAILWATER ELEV 40.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

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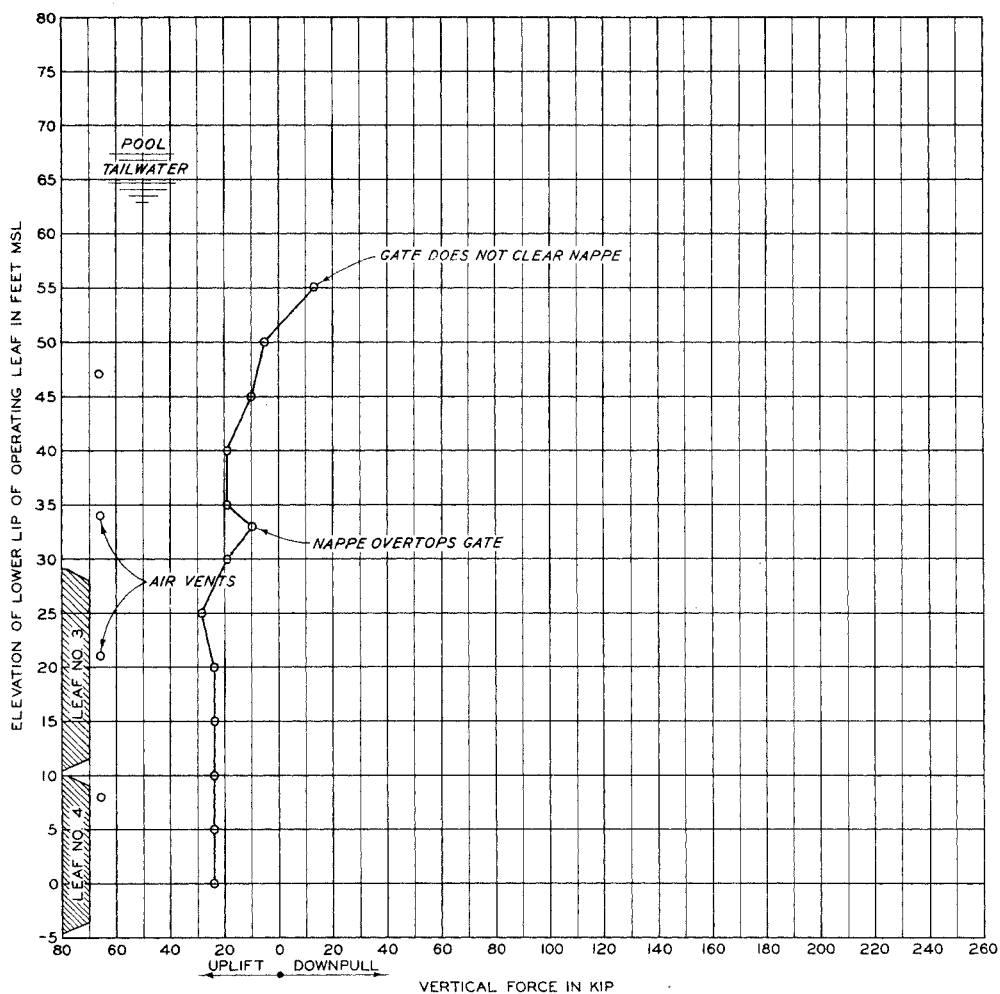
LEGEND

- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 CLOSING

POOL ELEV 40.0 FT MSL
TAILWATER ELEV 20.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

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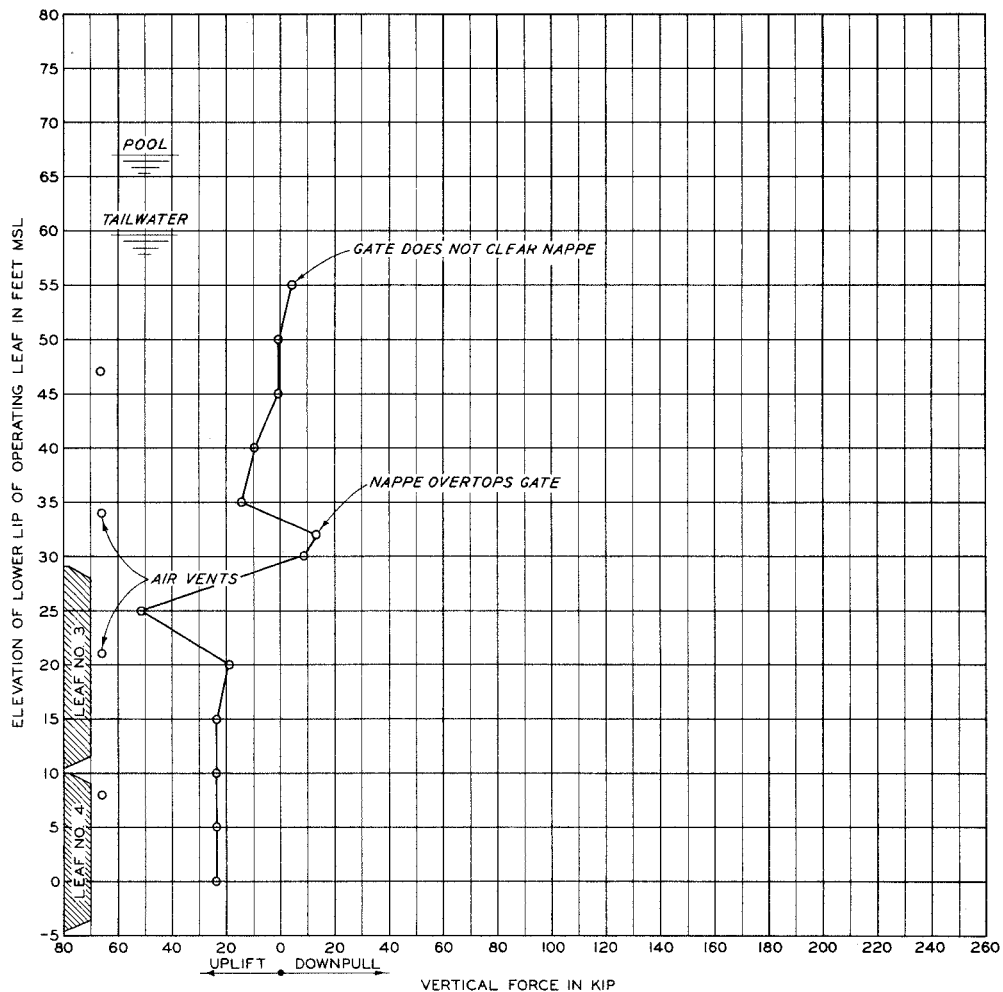
ALL BAYS CLOSED EXCEPT CENTER BAY (BAY NO. 6).

LEGEND
 ○ OBSERVED AVERAGE
 □ MAXIMUM
 △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 AND GATE LEAF NO. 4
FASTENED TOGETHER AND CLOSING

POOL ELEV 67.0 FT MSL
TAILWATER ELEV 65.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

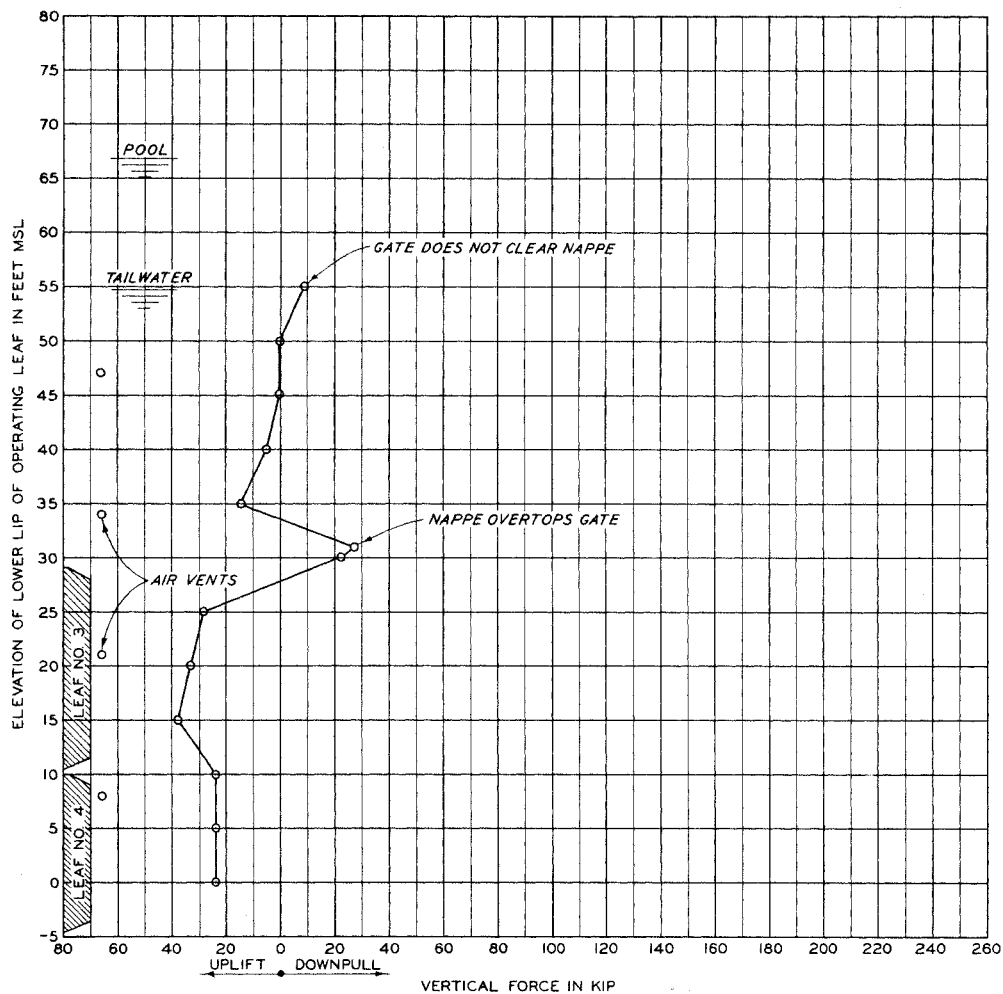
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LEGEND
 ○ OBSERVED AVERAGE
 □ MAXIMUM
 △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 AND GATE LEAF NO. 4
FASTENED TOGETHER AND CLOSING
 POOL ELEV 67.0 FT MSL
 TAILWATER ELEV 60.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

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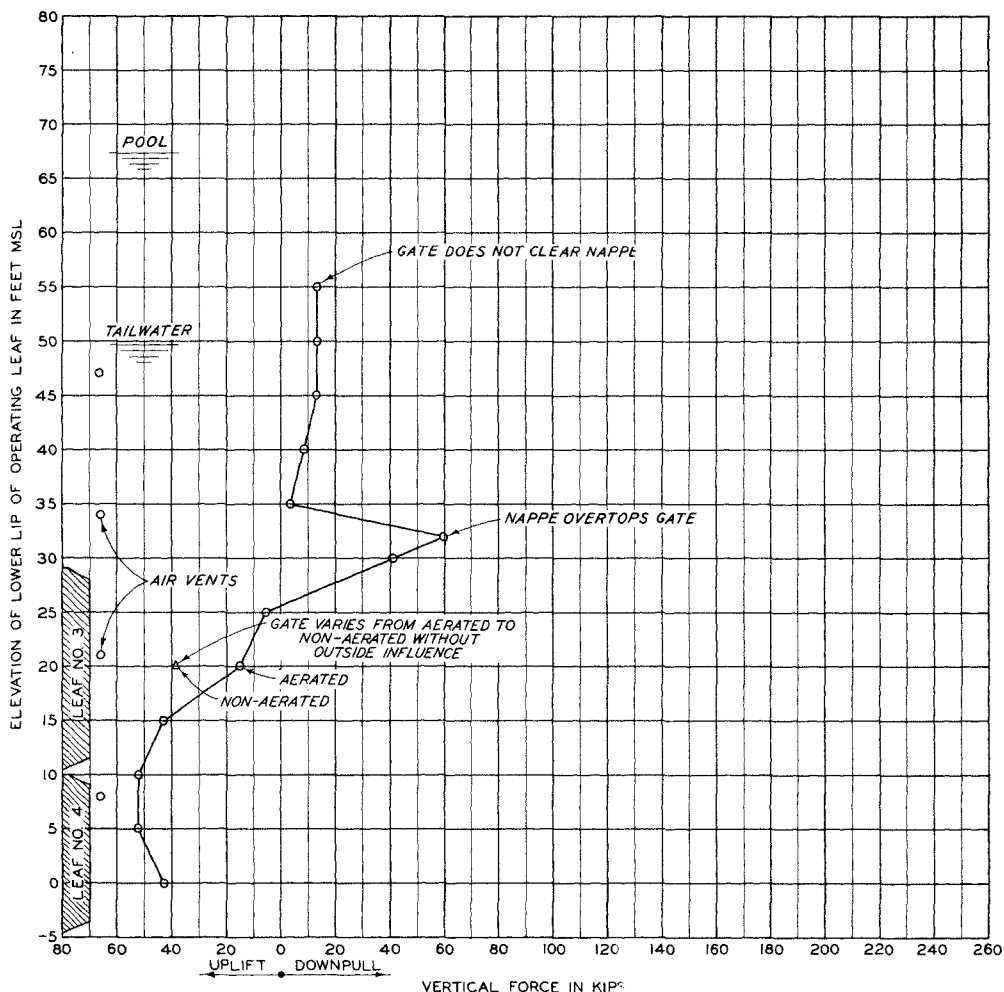
LEGEND

- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 AND GATE LEAF NO. 4
FASTENED TOGETHER AND CLOSING

POOL ELEV 67.0 FT MSL
TAILWATER ELEV 55.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

VERTICAL FORCES PLOTTED ARE EXTERNAL FORCES ACTING UPON THE GATE AS A RESULT OF FLOW OVER AND UNDER IT. IN ORDER TO OBTAIN THE TOTAL HOIST LOAD, THE DRY WEIGHT OF THE GATE SHOULD BE APPLIED TO THE FORCES SHOWN.

ALL BAYS CLOSED EXCEPT CENTER BAY (BAY NO. 6).

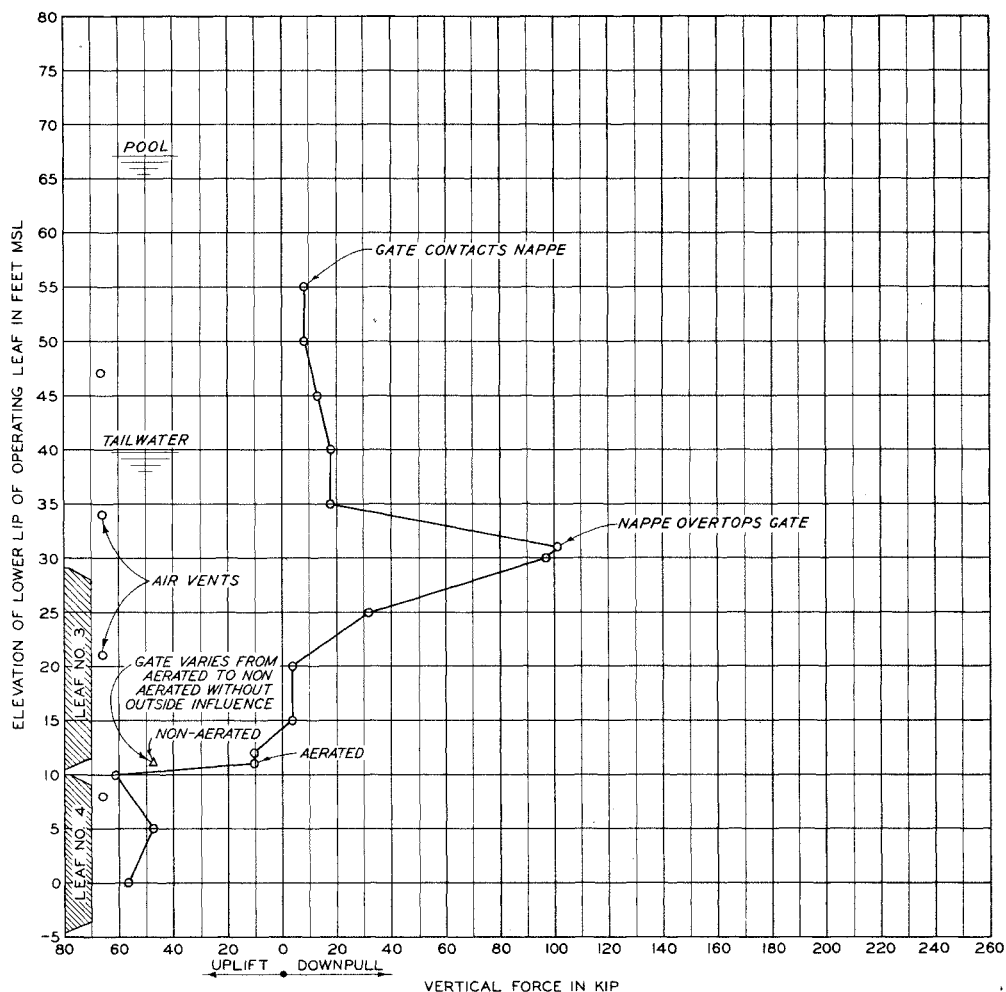
LEGEND

- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 AND GATE LEAF NO. 4
FASTENED TOGETHER AND CLOSING

POOL ELEV 67.0 FT MSL
TAILWATER ELEV 50.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

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ALL BAYS CLOSED EXCEPT CENTER BAY (BAY NO. 6).

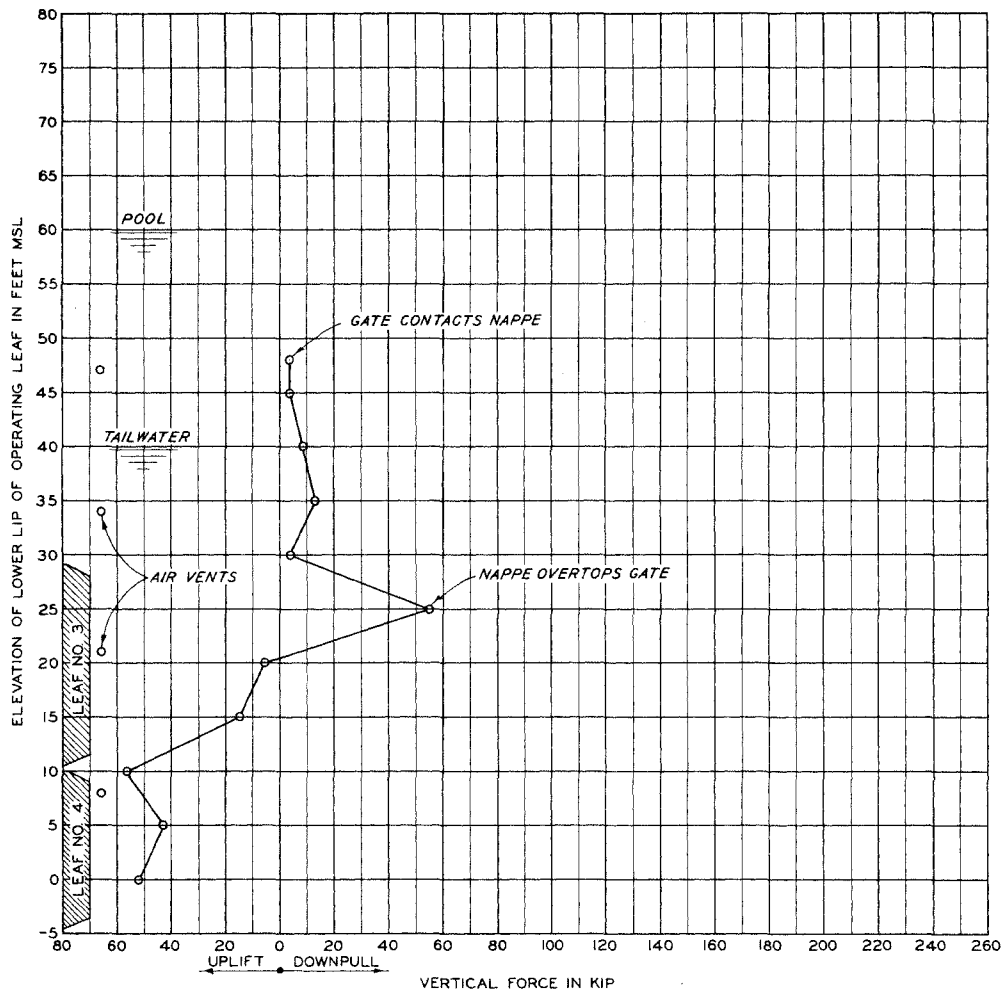
LEGEND

- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 AND GATE LEAF NO. 4
FASTENED TOGETHER AND CLOSING

POOL ELEV 67.0 FT MSL
TAILWATER ELEV 40.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

VERTICAL FORCES PLOTTED ARE EXTERNAL FORCES ACTING UPON THE GATE AS A RESULT OF FLOW OVER AND UNDER IT. IN ORDER TO OBTAIN THE TOTAL HOIST LOAD, THE DRY WEIGHT OF THE GATE SHOULD BE APPLIED TO THE FORCES SHOWN.

ALL BAYS CLOSED EXCEPT CENTER BAY (BAY NO. 6).

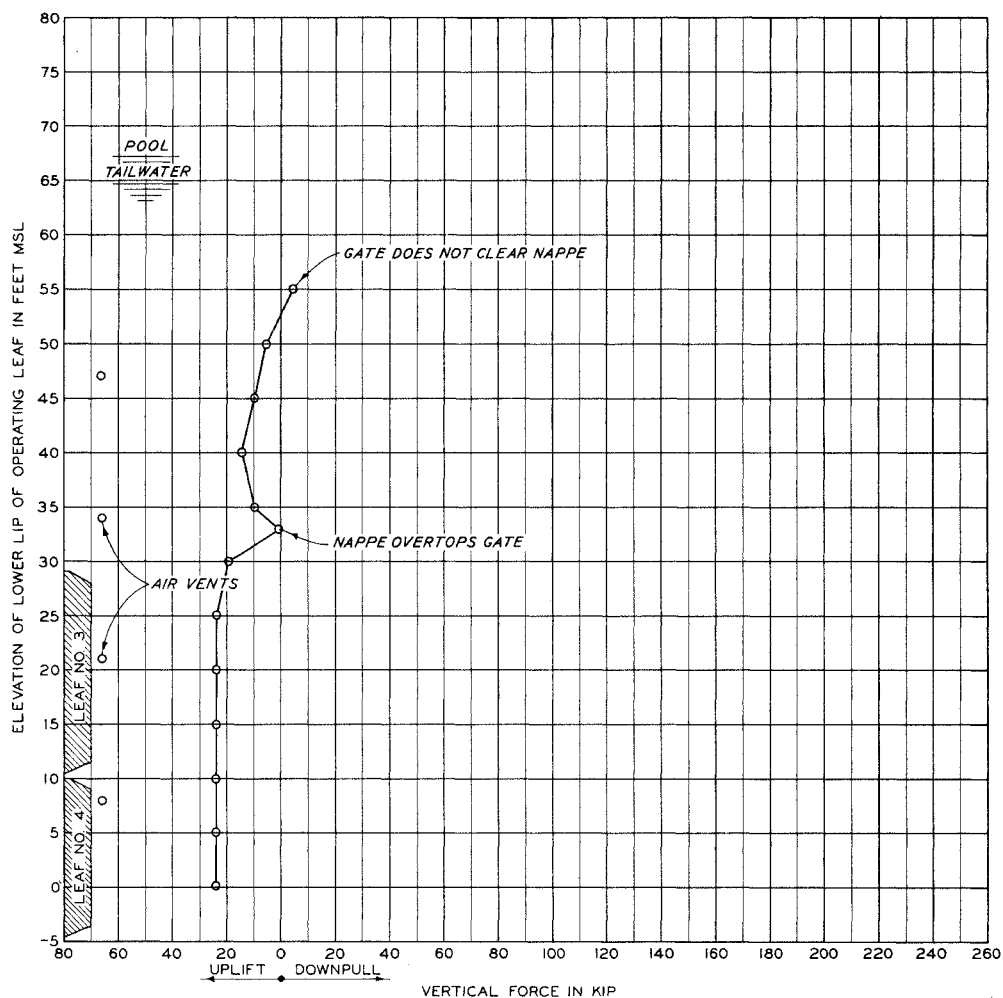
LEGEND

- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 AND GATE LEAF NO. 4
FASTENED TOGETHER AND CLOSING

POOL ELEV 60.0 FT MSL
TAILWATER ELEV 40.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

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ALL BAYS CLOSED EXCEPT THREE CENTER BAYS (BAYS NOS. 5, 6, 7).

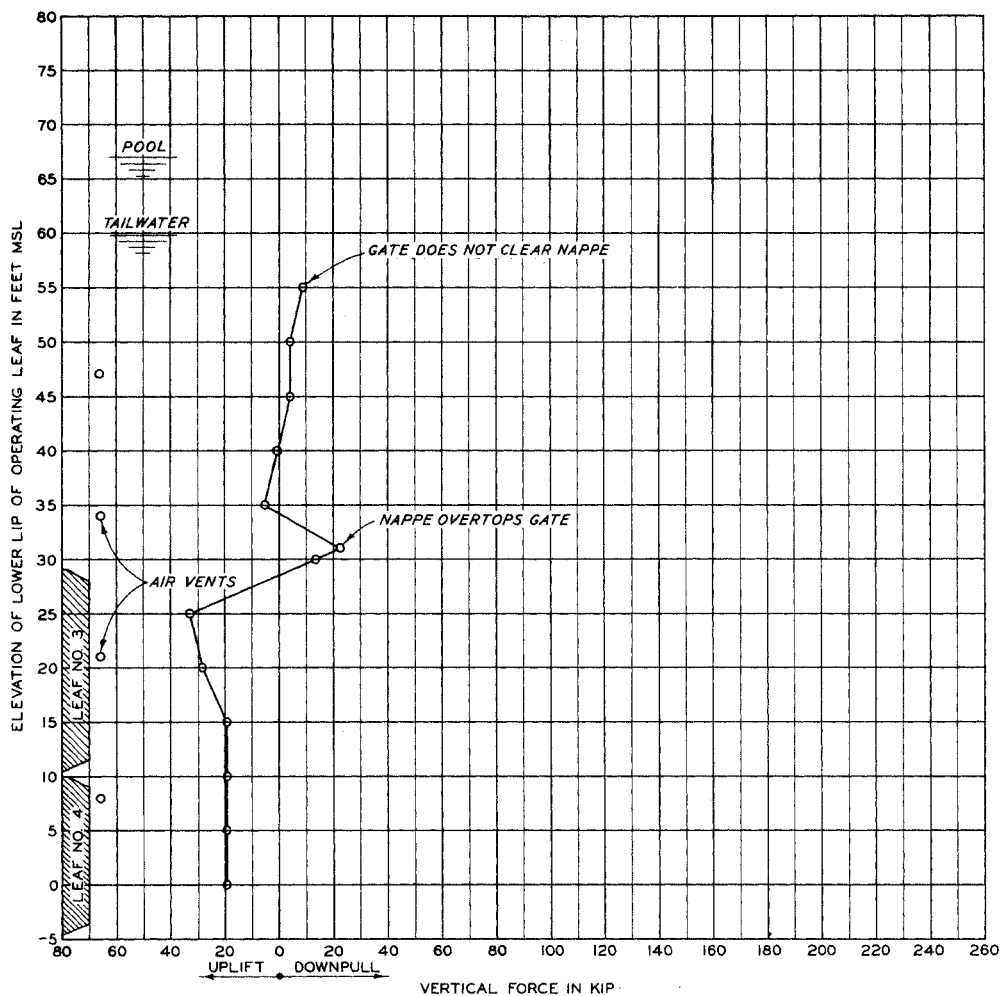
LEGEND

- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 AND GATE LEAF NO. 4
FASTENED TOGETHER AND CLOSING

POOL ELEV 67.0 FT MSL
TAILWATER ELEV 65.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

VERTICAL FORCES PLOTTED ARE EXTERNAL FORCES ACTING UPON THE GATE AS A RESULT OF FLOW OVER AND UNDER IT. IN ORDER TO OBTAIN THE TOTAL HOIST LOAD, THE DRY WEIGHT OF THE GATE SHOULD BE APPLIED TO THE FORCES SHOWN.

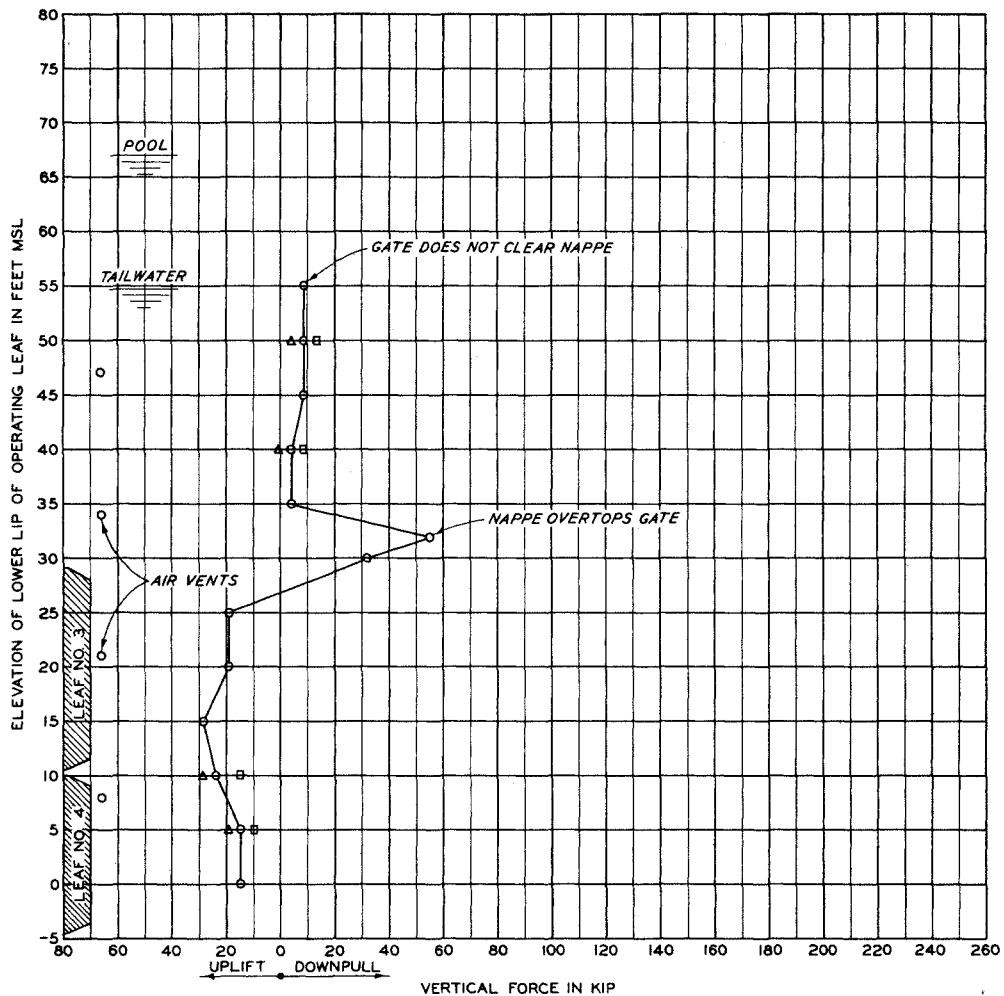
ALL BAYS CLOSED EXCEPT THREE CENTER BAYS (BAYS NOS. 5, 6, 7).

LEGEND
 O OBSERVED AVERAGE
 □ MAXIMUM
 Δ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 AND GATE LEAF NO. 4
FASTENED TOGETHER AND CLOSING

POOL ELEV 67.0 FT MSL
TAILWATER ELEV 60.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

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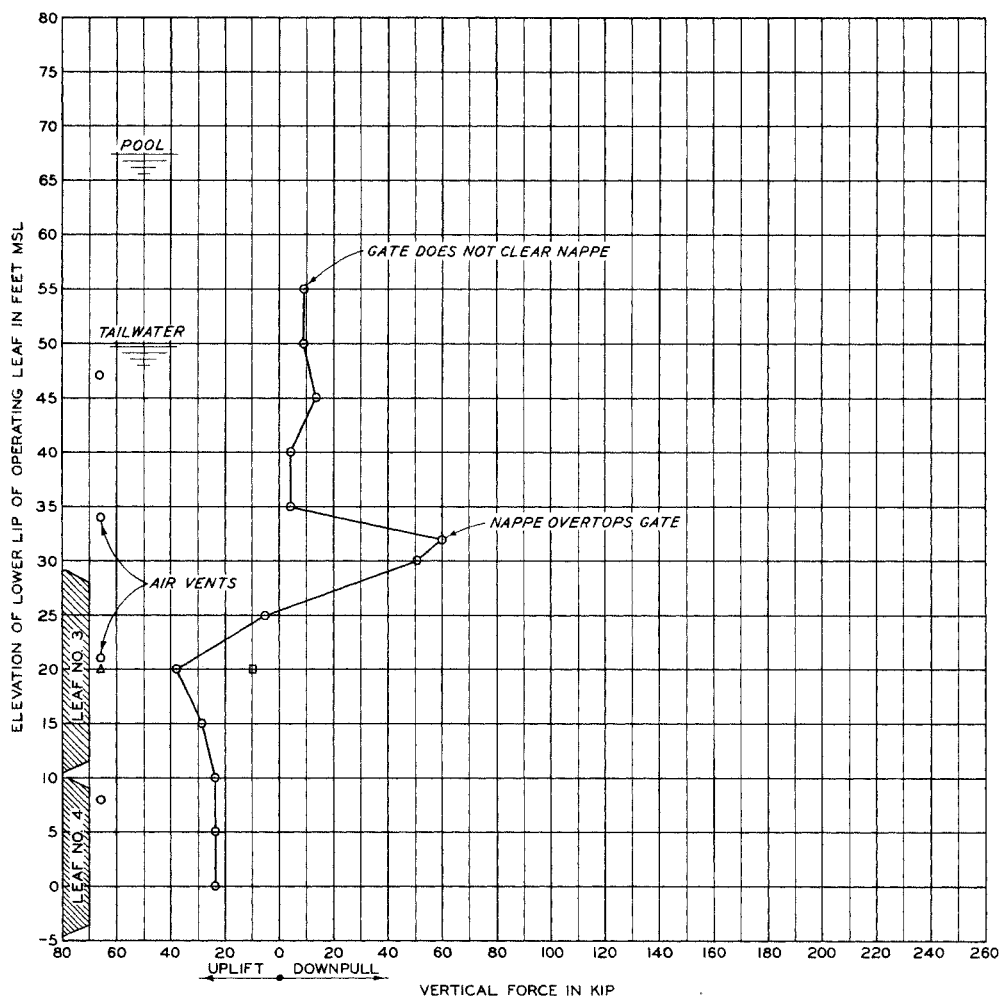
LEGEND

- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 AND GATE LEAF NO. 4
FASTENED TOGETHER AND CLOSING

POOL ELEV 67.0 FT MSL
TAILWATER ELEV 55.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

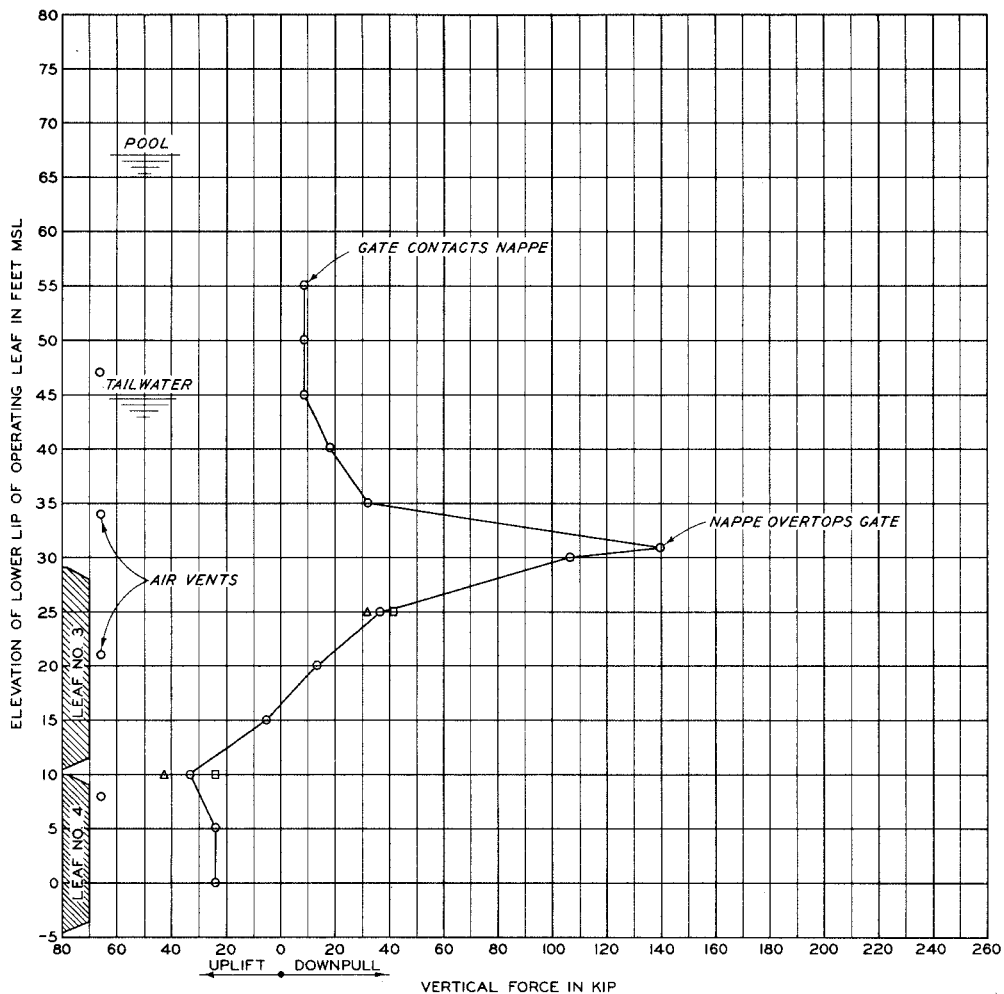
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ALL BAYS CLOSED EXCEPT THREE CENTER BAYS (BAYS NOS. 5, 6, 7).

LEGEND
 O OBSERVED AVERAGE
 □ MAXIMUM
 △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 AND GATE LEAF NO. 4
FASTENED TOGETHER AND CLOSING
 POOL ELEV 67.0 FT MSL
 TAILWATER ELEV 50.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

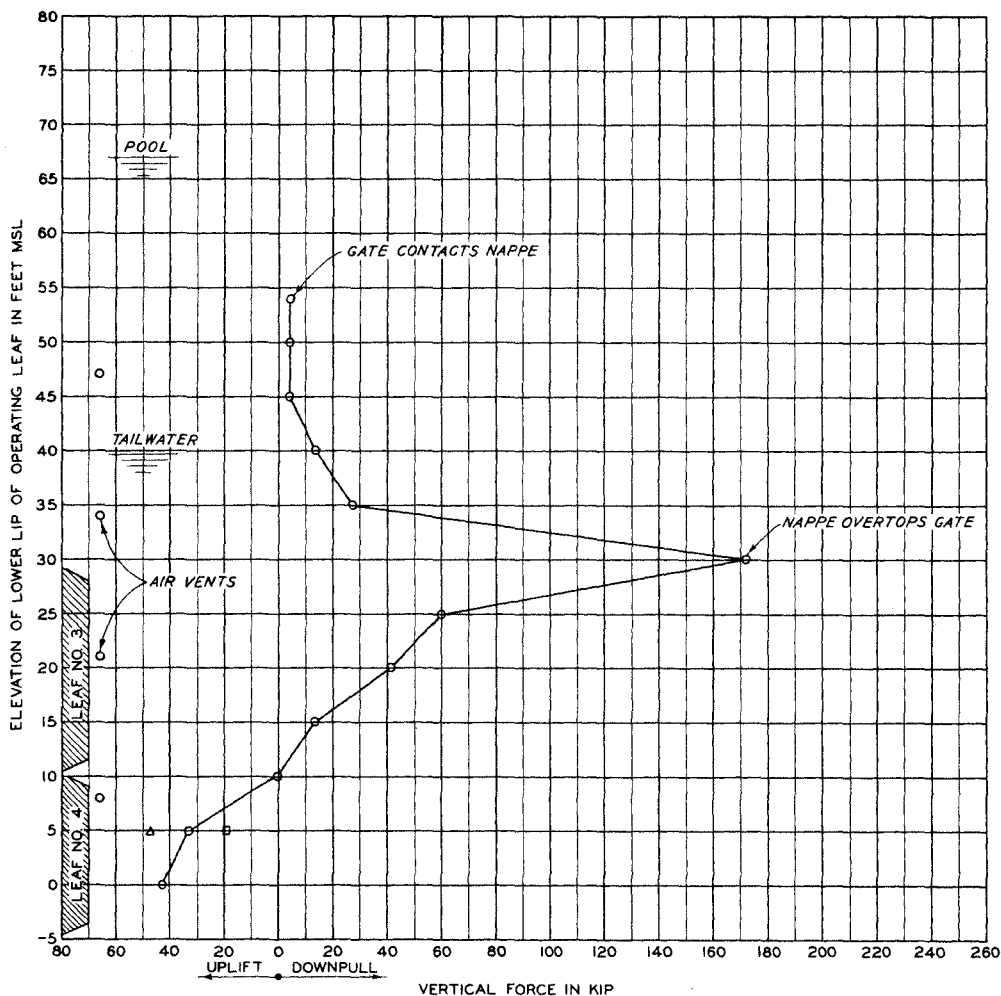
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ALL BAYS CLOSED EXCEPT THREE CENTER BAYS (BAYS NOS. 5, 6, 7).

LEGEND
 ○ OBSERVED AVERAGE
 □ MAXIMUM
 △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 AND GATE LEAF NO. 4
FASTENED TOGETHER AND CLOSING
 POOL ELEV 67.0 FT MSL
 TAILWATER ELEV 45.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

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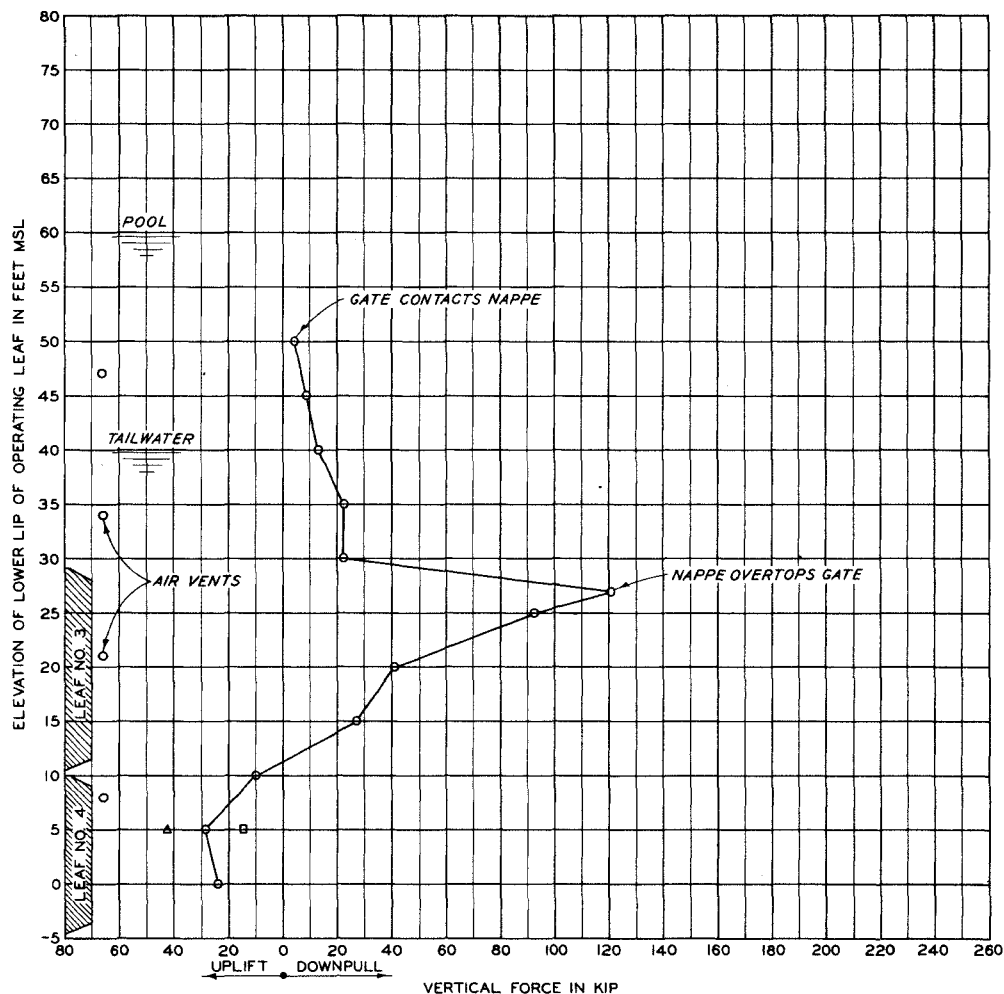
ALL BAYS CLOSED EXCEPT THREE CENTER BAYS (BAYS NOS. 5, 6, 7).

LEGEND
 O OBSERVED AVERAGE
 □ MAXIMUM
 △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 AND GATE LEAF NO. 4
FASTENED TOGETHER AND CLOSING

POOL ELEV 67.0 FT MSL
TAILWATER ELEV 40.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

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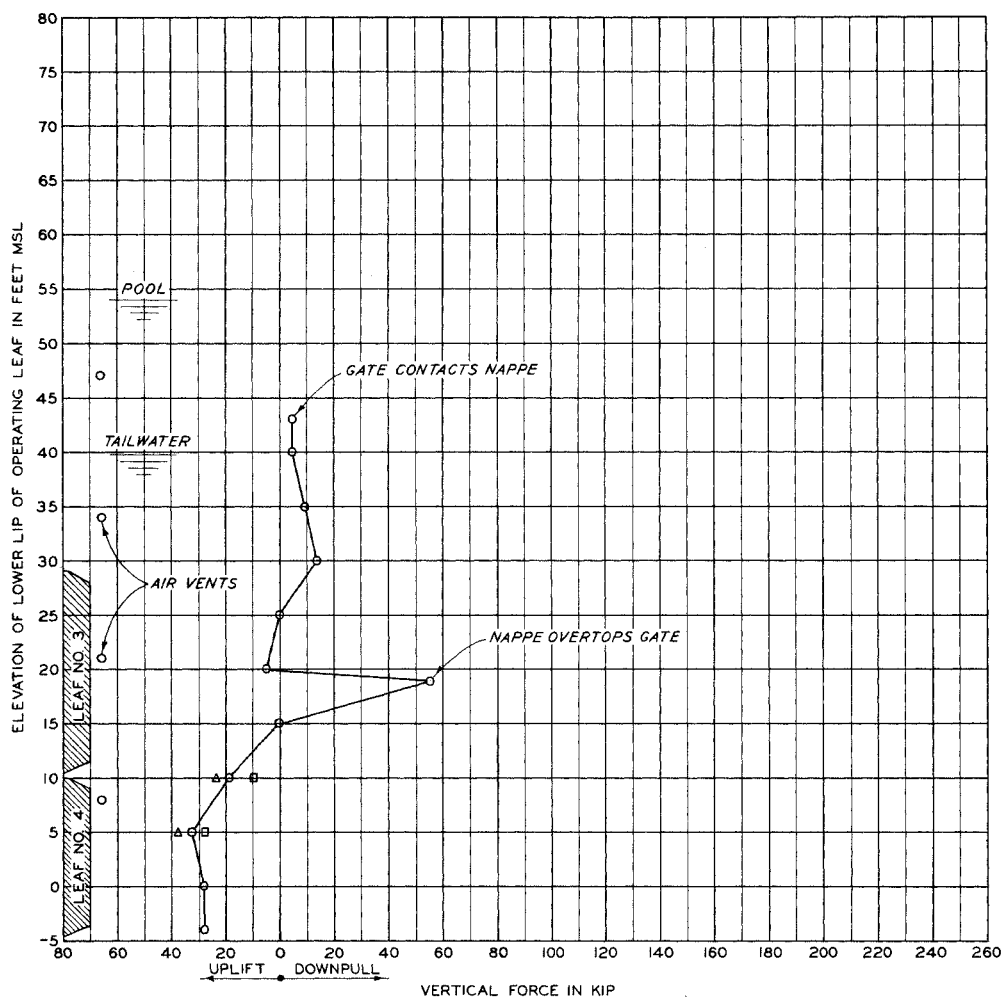
LEGEND

- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 AND GATE LEAF NO. 4
FASTENED TOGETHER AND CLOSING

POOL ELEV 60.0 FT MSL
TAILWATER ELEV 40.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

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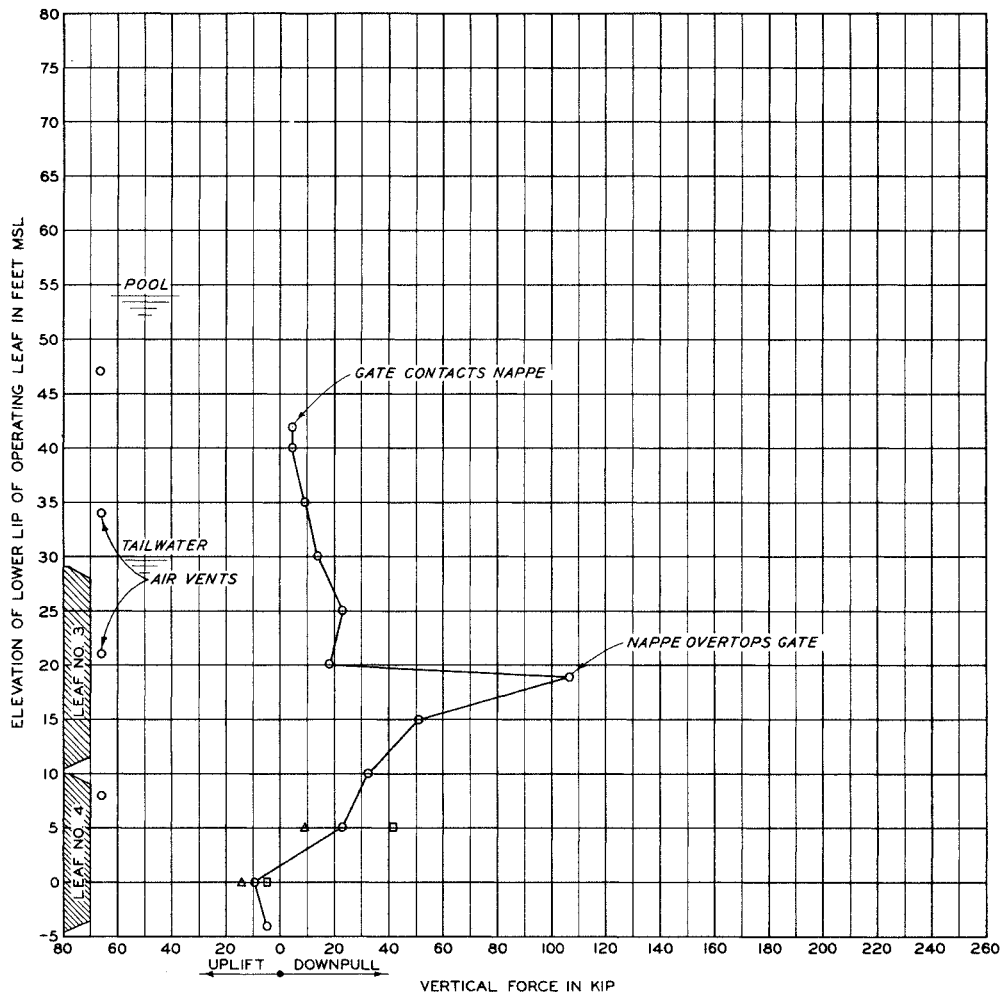
ALL BAYS CLOSED EXCEPT CENTER BAY (BAY NO. 6).

LEGEND
 ○ OBSERVED AVERAGE
 □ MAXIMUM
 △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 AND GATE LEAF NO. 4
FASTENED TOGETHER AND CLOSING

POOL ELEV 54.0 FT MSL
TAILWATER ELEV 40.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

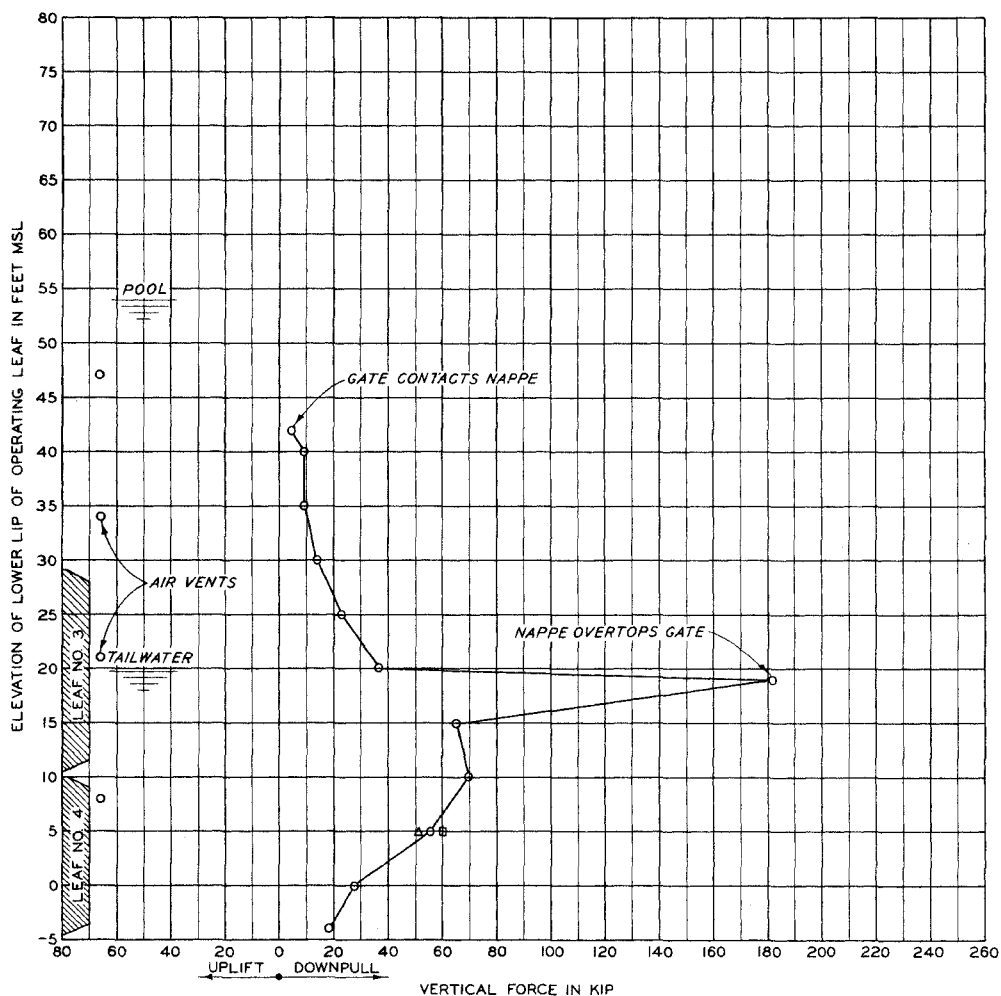
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ALL BAYS CLOSED EXCEPT CENTER BAY (BAY NO. 6).

LEGEND
 ○ OBSERVED AVERAGE
 □ MAXIMUM
 △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 AND GATE LEAF NO. 4
 FASTENED TOGETHER AND CLOSING
 POOL ELEV 54.0 FT MSL
 TAILWATER ELEV 30.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

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ALL BAYS CLOSED EXCEPT CENTER BAY (BAY NO. 6)

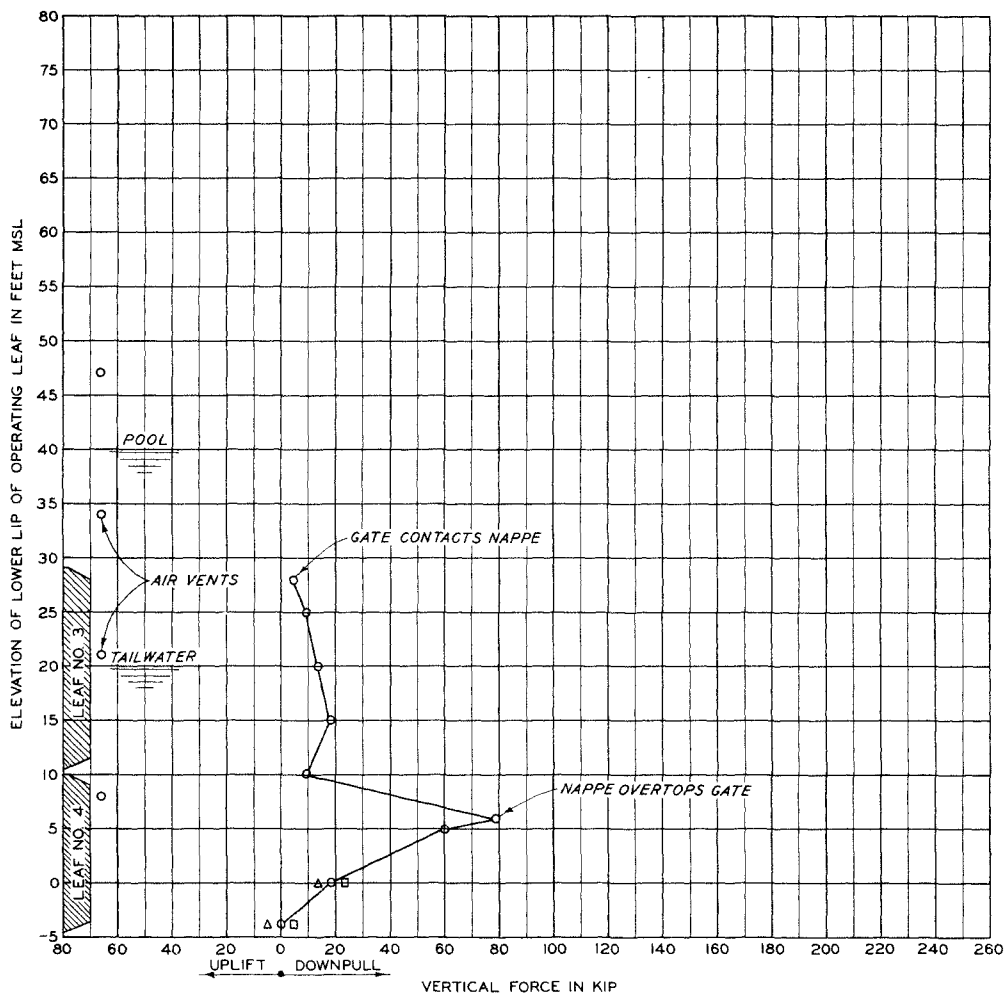
LEGEND

- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 AND GATE LEAF NO. 4
FASTENED TOGETHER AND CLOSING

POOL ELEV 54.0 FT MSL
TAILWATER ELEV 20.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

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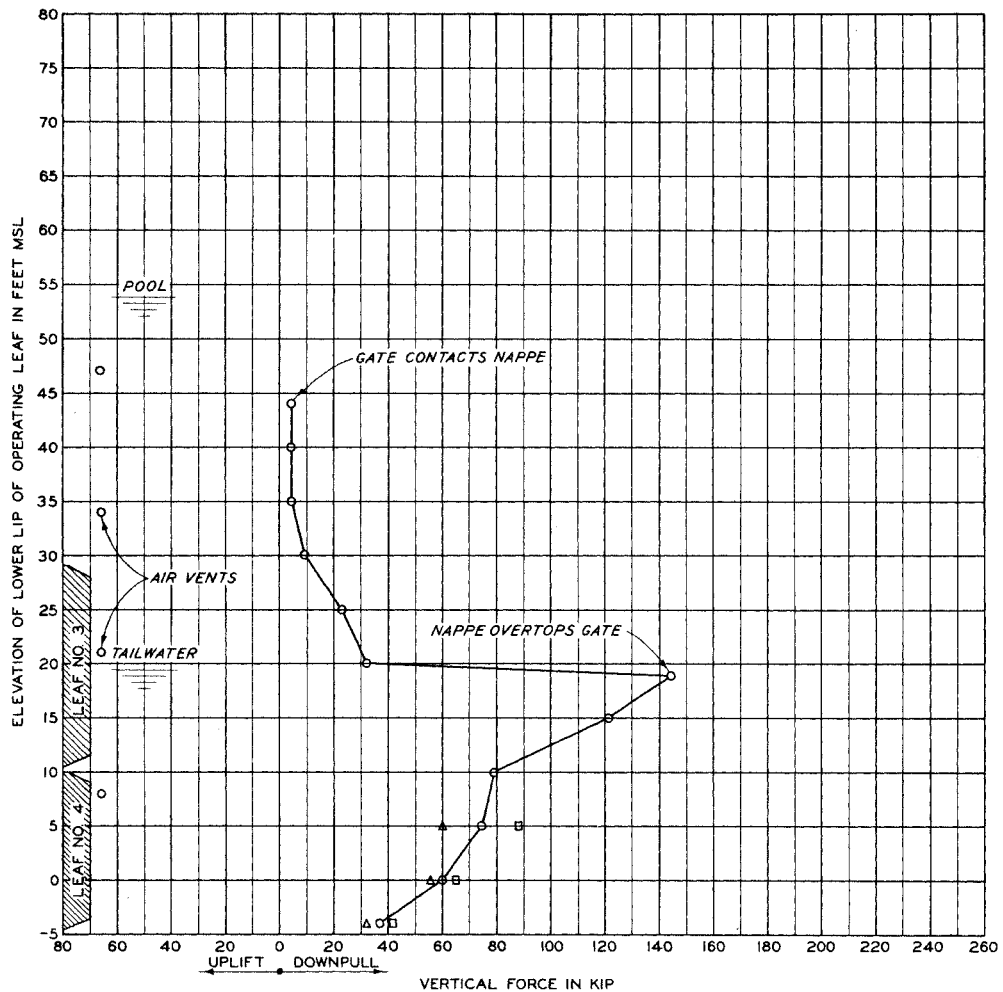
LEGEND

- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 AND GATE LEAF NO. 4
FASTENED TOGETHER AND CLOSING

POOL ELEV 40.0 FT MSL
TAILWATER ELEV 20.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

VERTICAL FORCES PLOTTED ARE EXTERNAL FORCES ACTING UPON THE GATE AS A RESULT OF FLOW OVER AND UNDER IT. IN ORDER TO OBTAIN THE TOTAL HOIST LOAD, THE DRY WEIGHT OF THE GATE SHOULD BE APPLIED TO THE FORCES SHOWN.

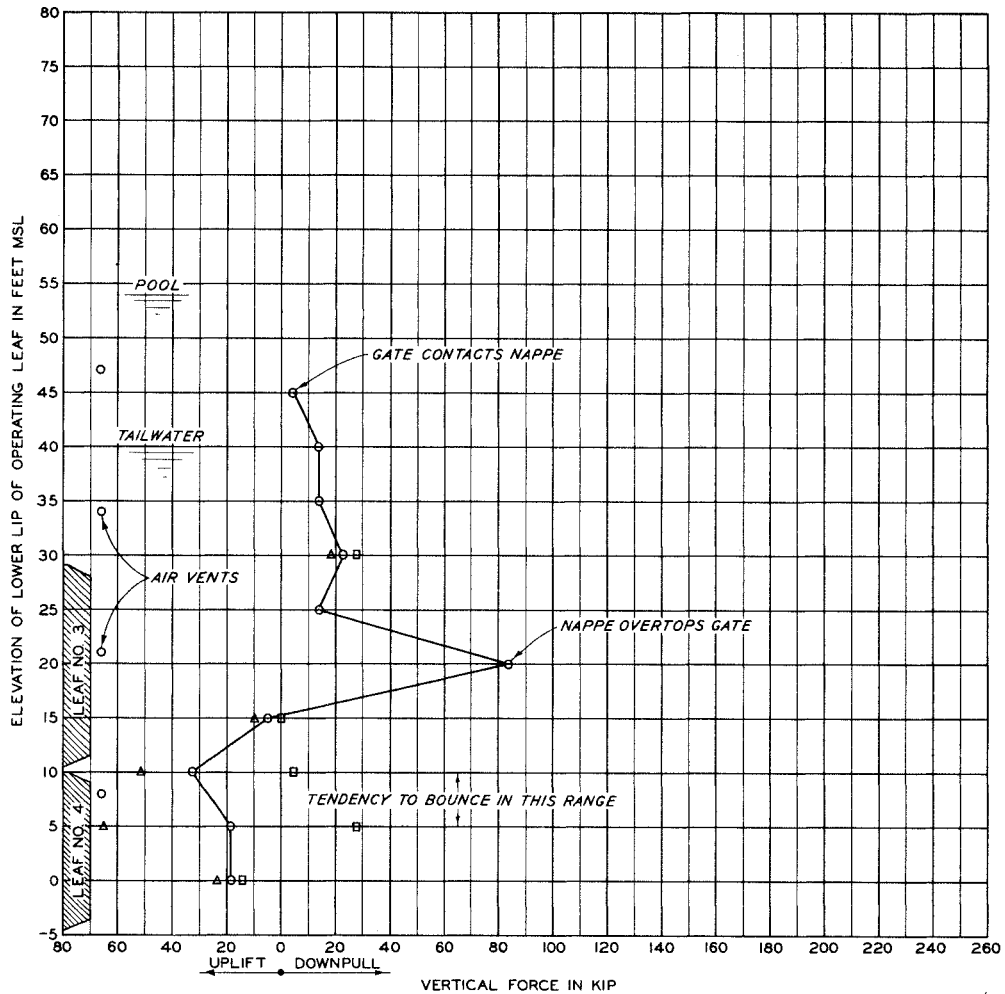
ALL BAYS CLOSED EXCEPT TWO CENTER BAYS (BAYS NOS. 5, 6)

LEGEND
 ○ OBSERVED AVERAGE
 □ MAXIMUM
 △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 AND GATE LEAF NO. 4
 FASTENED TOGETHER AND CLOSING

POOL ELEV 54.0 FT MSL
 TAILWATER ELEV 20.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

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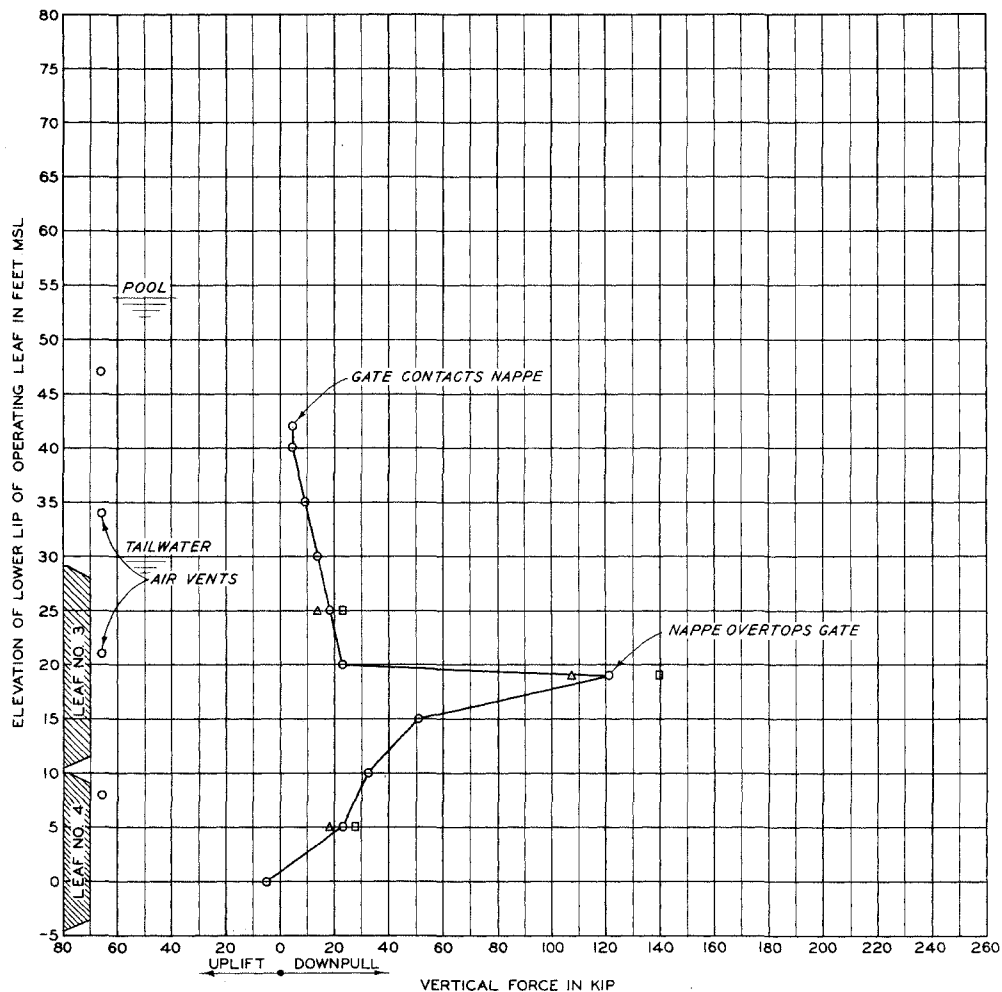
LEGEND

- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 AND GATE LEAF NO. 4
FASTENED TOGETHER AND CLOSING

POOL ELEV 54.0 FT MSL
TAILWATER ELEV 40.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

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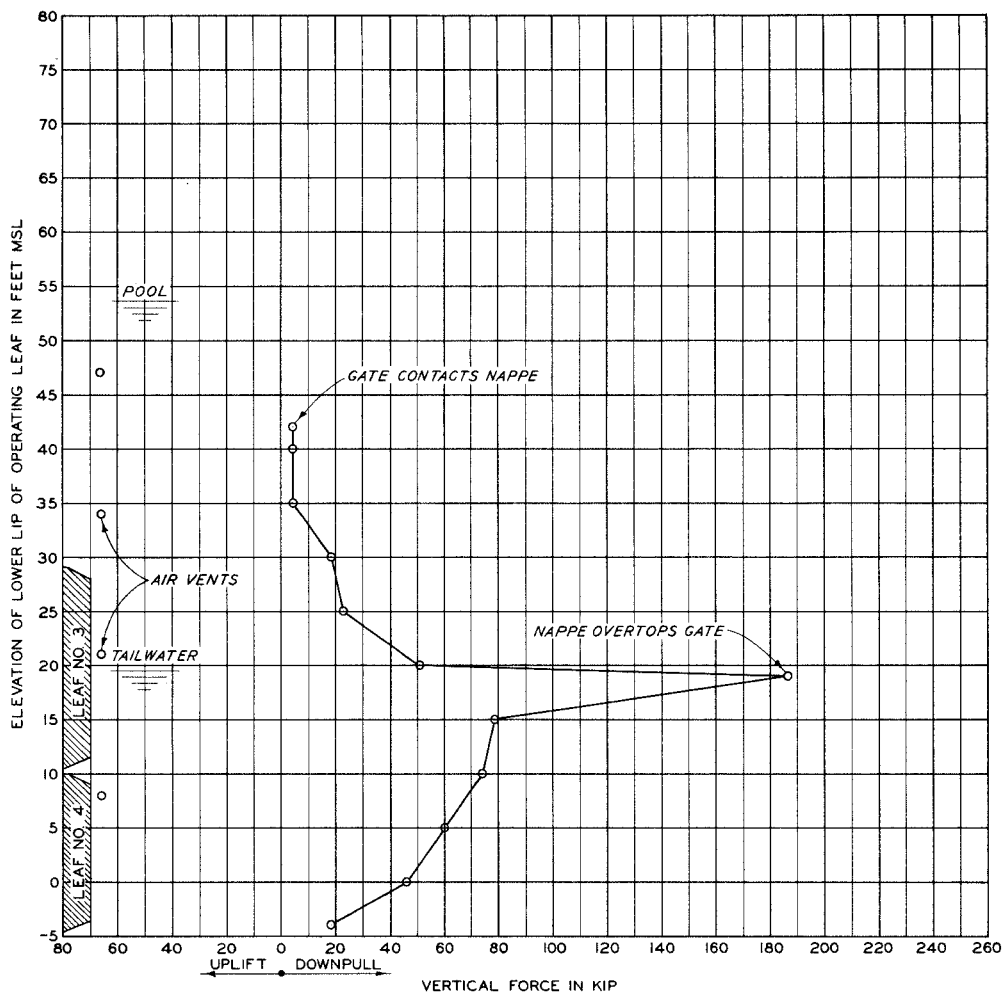
ALL BAYS CLOSED EXCEPT THREE CENTER BAYS (BAYS NOS. 5, 6, 7).

LEGEND
 ○ OBSERVED AVERAGE
 □ MAXIMUM
 △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

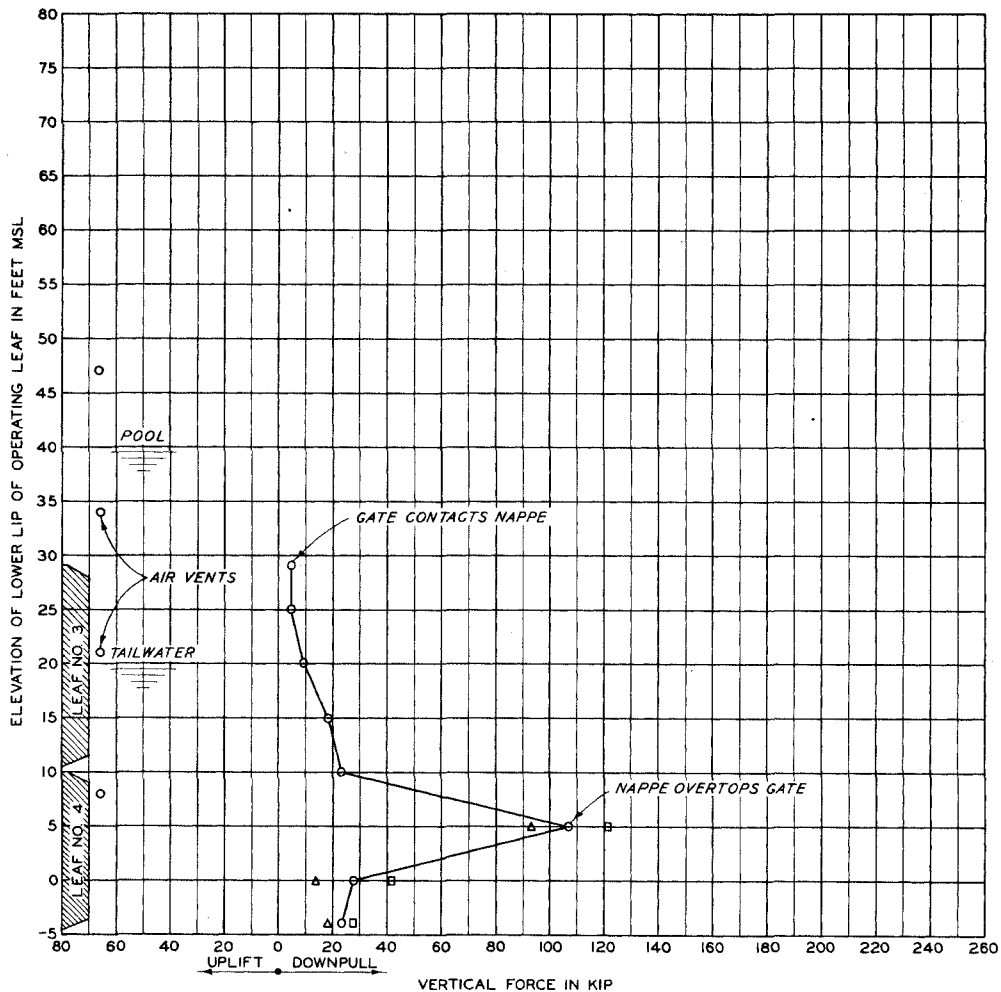
GATE LEAF NO. 3 AND GATE LEAF NO. 4
FASTENED TOGETHER AND CLOSING

POOL ELEV 54.0 FT MSL
TAILWATER ELEV 30.0 FT MSL



VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 AND GATE LEAF NO. 4
 FASTENED TOGETHER AND CLOSING
 POOL ELEV 54.0 FT MSL
 TAILWATER ELEV 20.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

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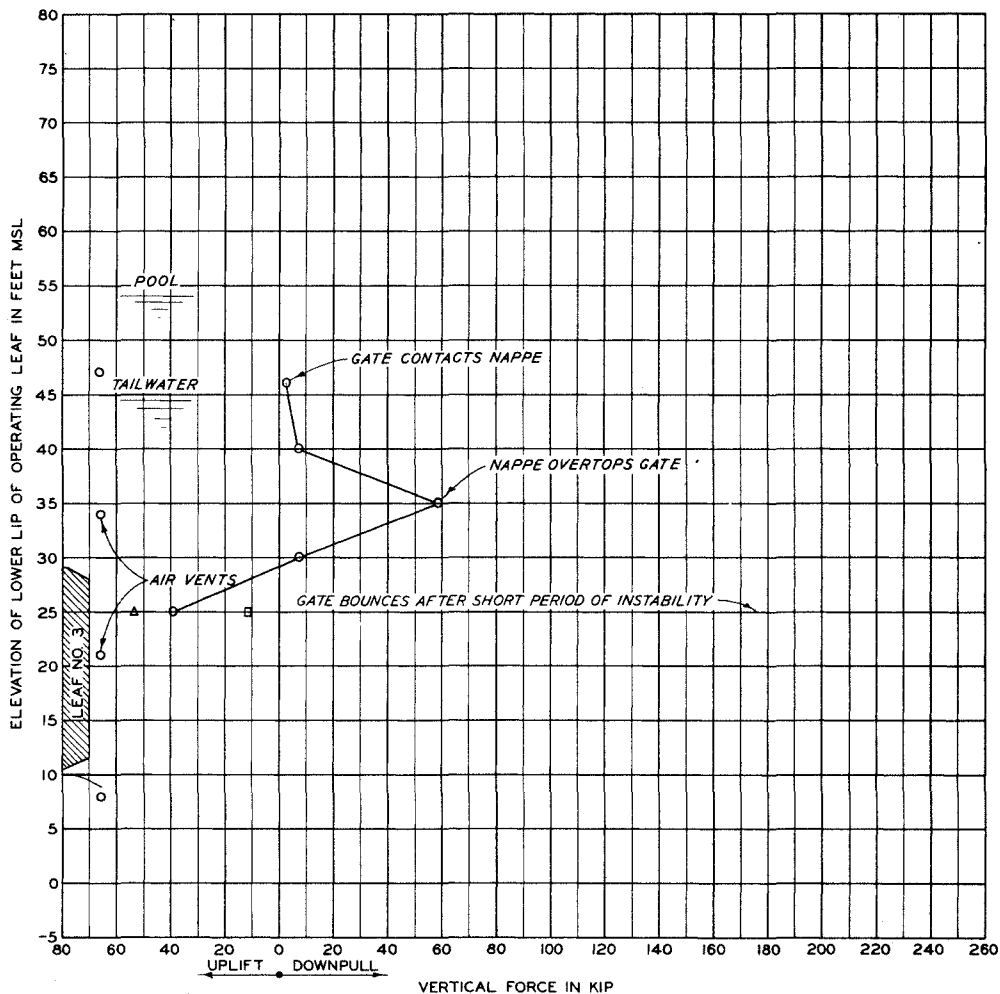
ALL BAYS CLOSED EXCEPT THREE CENTER BAYS (BAYS NOS. 5, 6, 7)

LEGEND
 O OBSERVED AVERAGE
 □ MAXIMUM
 Δ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 AND GATE LEAF NO. 4
 FASTENED TOGETHER AND CLOSING

POOL ELEV 40.0 FT MSL
 TAILWATER ELEV 20.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

VERTICAL FORCES PLOTTED ARE EXTERNAL FORCES ACTING UPON THE GATE AS A RESULT OF FLOW OVER AND UNDER IT. IN ORDER TO OBTAIN THE TOTAL HOIST LOAD, THE DRY WEIGHT OF THE GATE SHOULD BE APPLIED TO THE FORCES SHOWN.

ALL BAYS CLOSED EXCEPT BAY NO. 9.

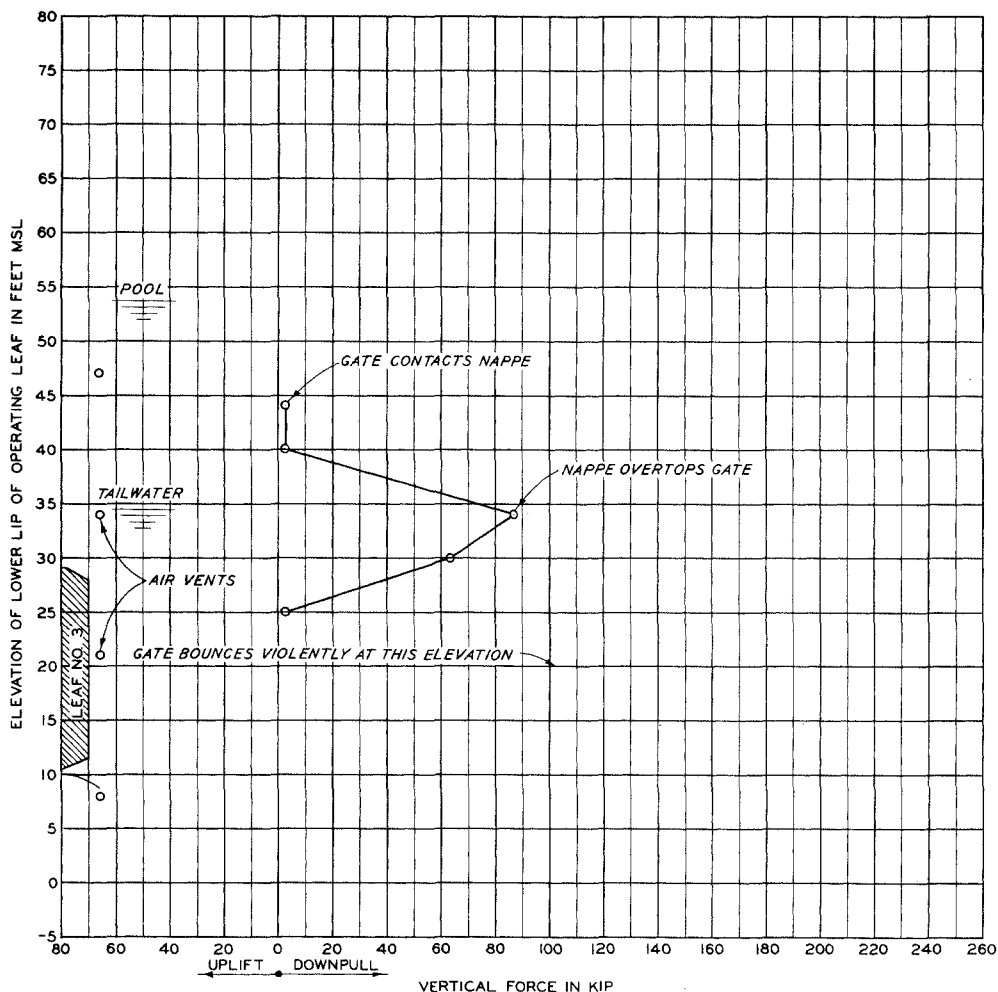
LEGEND

- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 CLOSING

POOL ELEV 54.0 FT MSL
TAILWATER ELEV 45.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

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ALL BAYS CLOSED EXCEPT BAY NO. 9

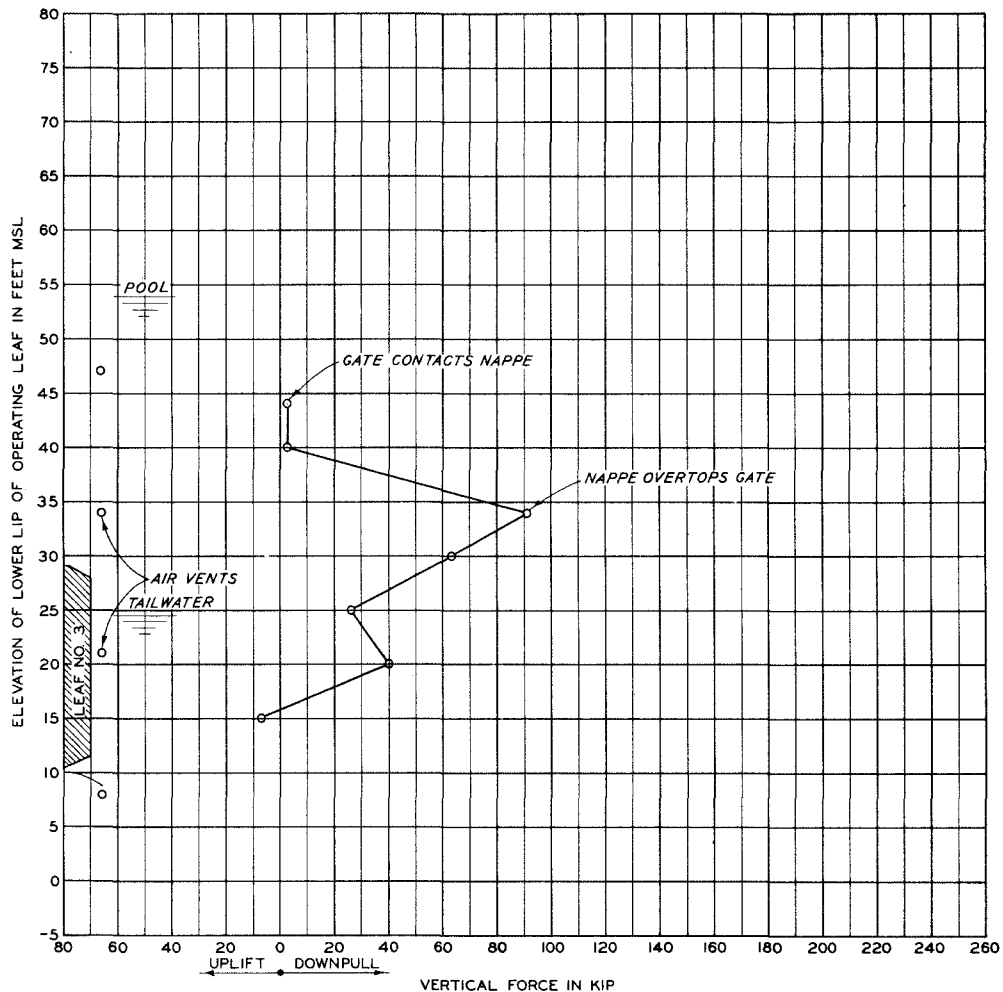
LEGEND

- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 CLOSING

POOL ELEV 54.0 FT MSL
TAILWATER ELEV 35.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

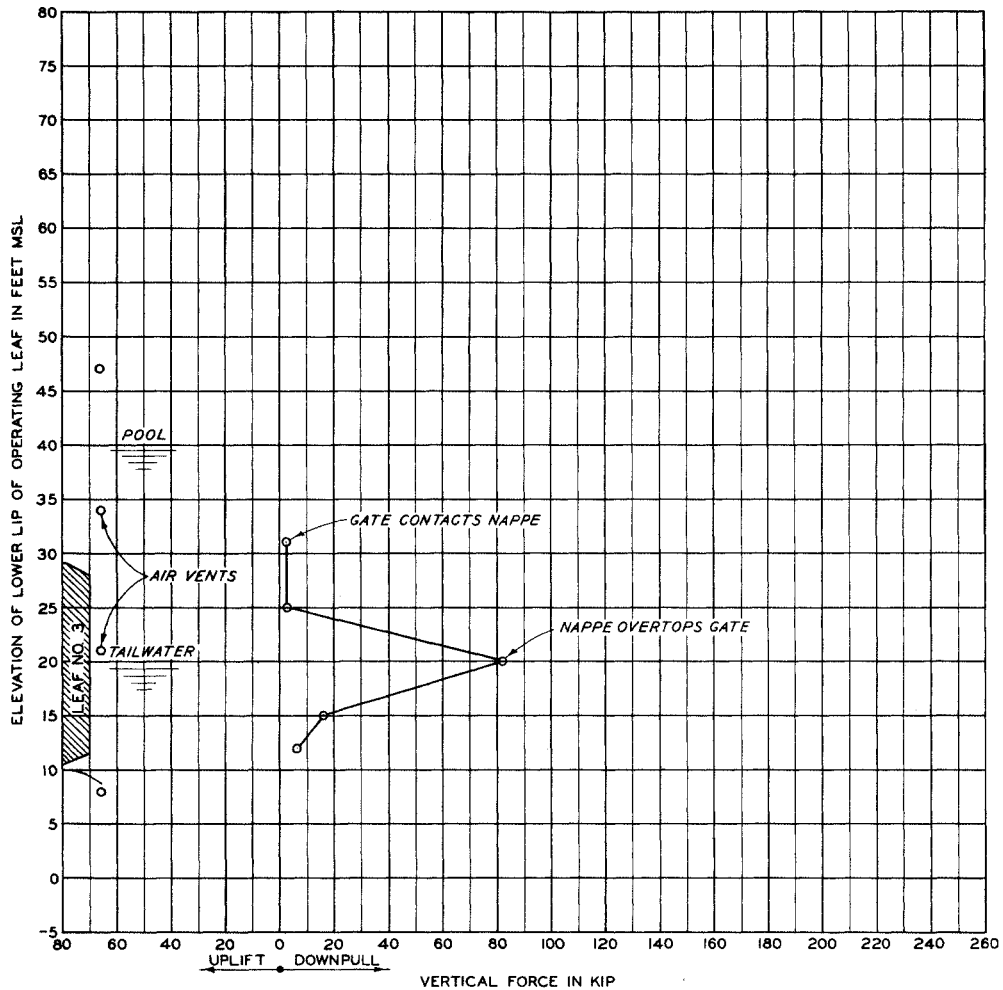
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ALL BAYS CLOSED EXCEPT BAY NO. 9

LEGEND
 ○ OBSERVED AVERAGE
 □ MAXIMUM
 △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF GATE LEAF NO. 3 CLOSING

POOL ELEV 54.0 FT MSL
 TAILWATER ELEV 25.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

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LEGEND

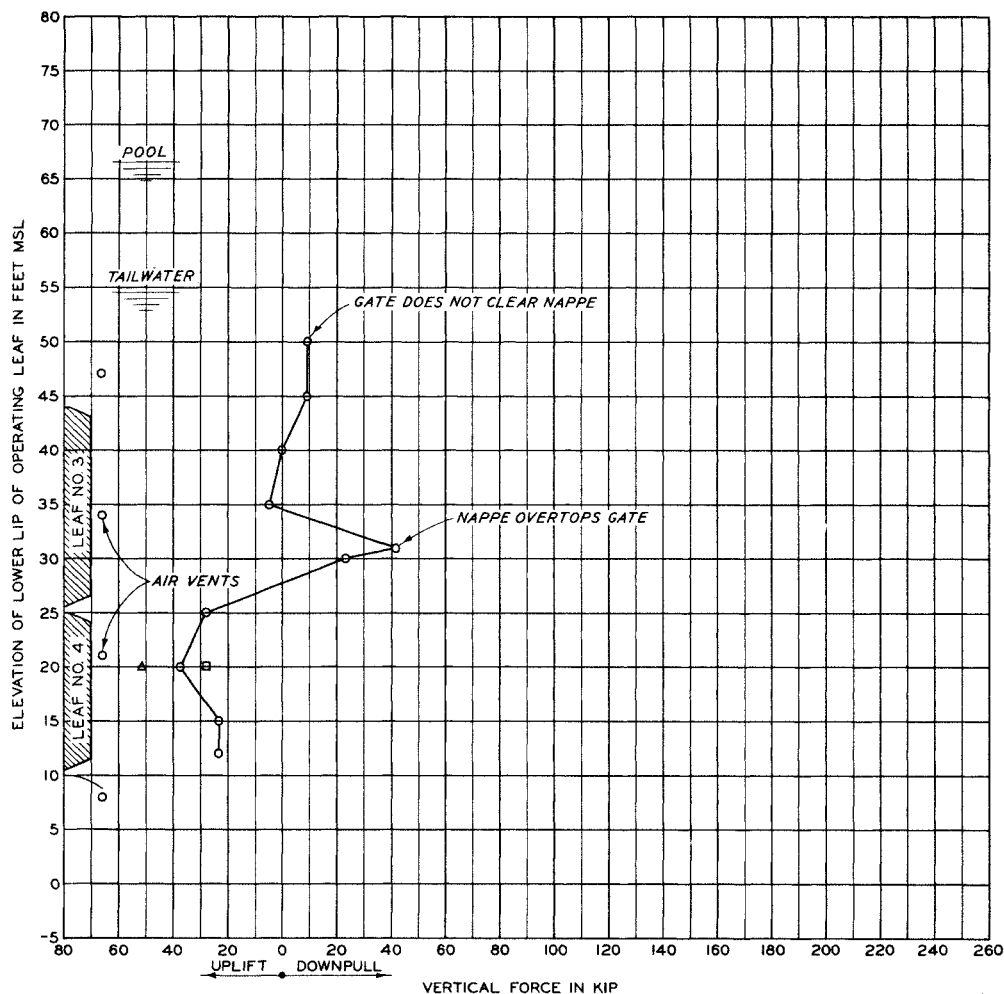
- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 CLOSING

ALL BAYS CLOSED EXCEPT BAY NO. 9

POOL ELEV 40.0 FT MSL
TAILWATER ELEV 20.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

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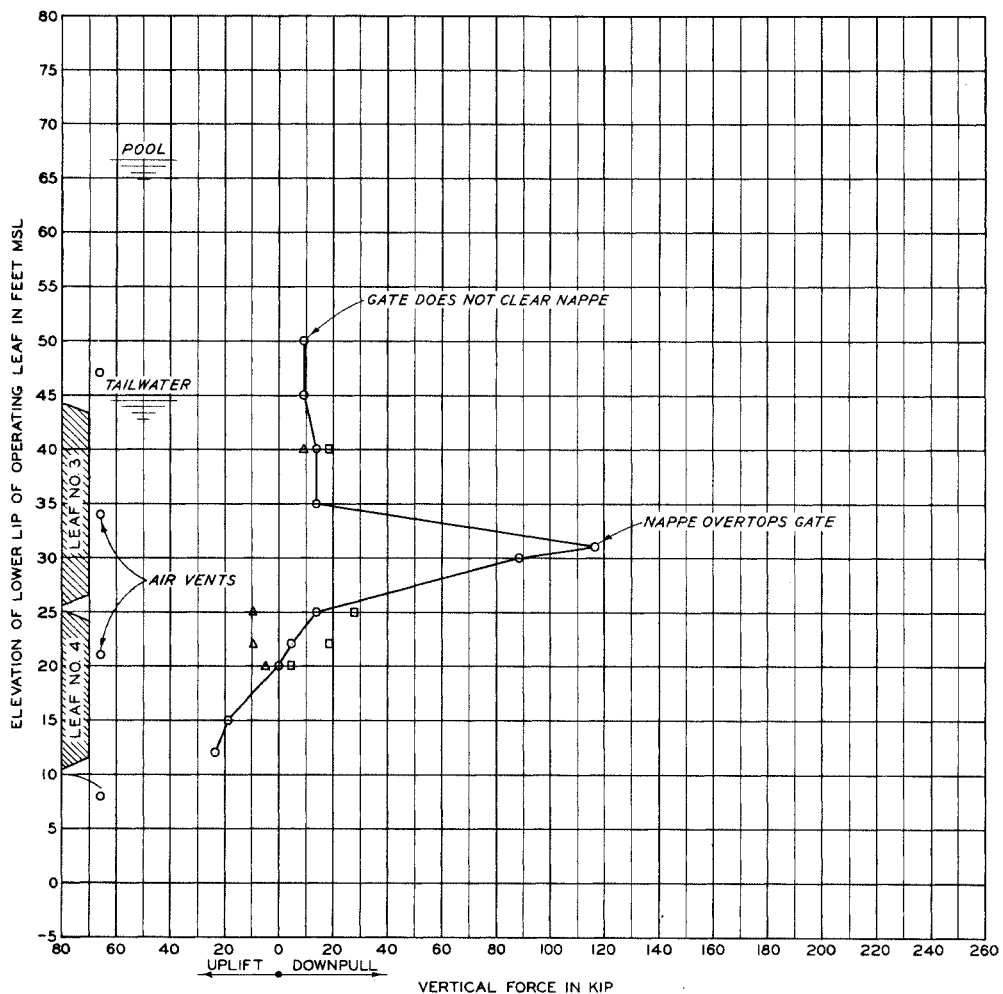
LEGEND
 O OBSERVED AVERAGE
 □ MAXIMUM
 Δ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 AND GATE LEAF NO. 4
FASTENED TOGETHER AND CLOSING

ALL BAYS CLOSED EXCEPT BAY NO. 9

POOL ELEV 67.0 FT MSL
TAILWATER ELEV 55.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

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LEGEND

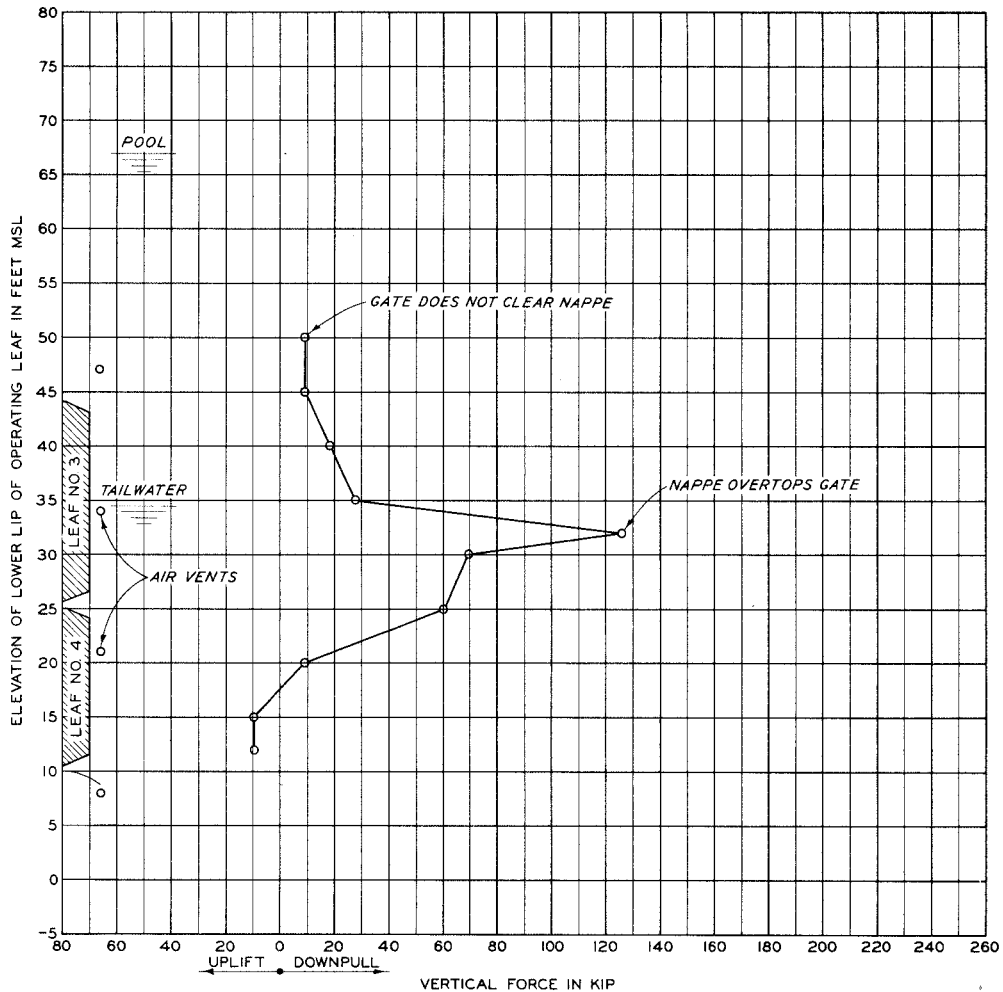
- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 AND GATE LEAF NO. 4
FASTENED TOGETHER AND CLOSING

ALL BAYS CLOSED EXCEPT BAY NO. 9

POOL ELEV 67.0 FT MSL
TAILWATER ELEV 45.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

VERTICAL FORCES PLOTTED ARE EXTERNAL FORCES ACTING UPON THE GATE AS A RESULT OF FLOW OVER AND UNDER IT. IN ORDER TO OBTAIN THE TOTAL HOIST LOAD, THE DRY WEIGHT OF THE GATE SHOULD BE APPLIED TO THE FORCES SHOWN.

ALL BAYS CLOSED EXCEPT BAY NO. 9.

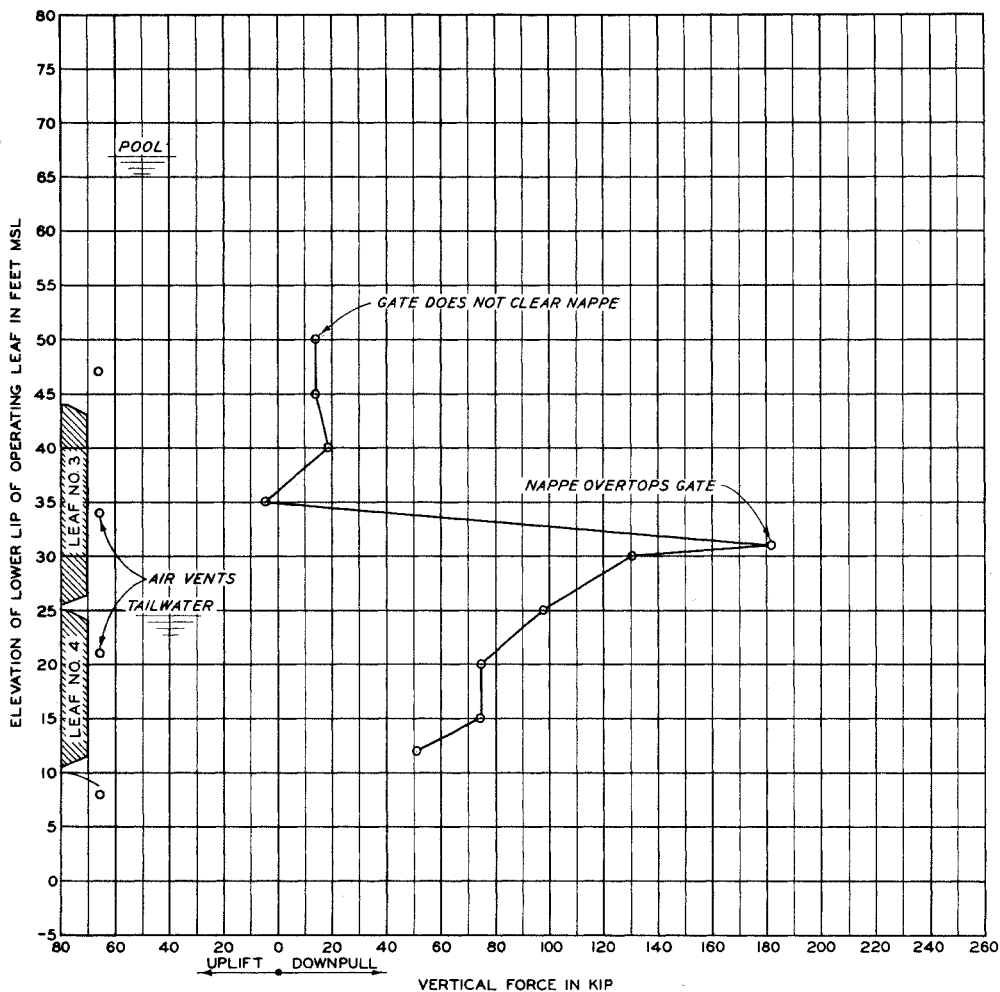
LEGEND

- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 AND GATE LEAF NO. 4
FASTENED TOGETHER AND CLOSING

POOL ELEV 67.0 FT MSL
TAILWATER ELEV 35.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

VERTICAL FORCES PLOTTED ARE EXTERNAL FORCES ACTING UPON THE GATE AS A RESULT OF FLOW OVER AND UNDER IT. IN ORDER TO OBTAIN THE TOTAL HOIST LOAD, THE DRY WEIGHT OF THE GATE SHOULD BE APPLIED TO THE FORCES SHOWN.

ALL BAYS CLOSED EXCEPT BAY NO. 9.

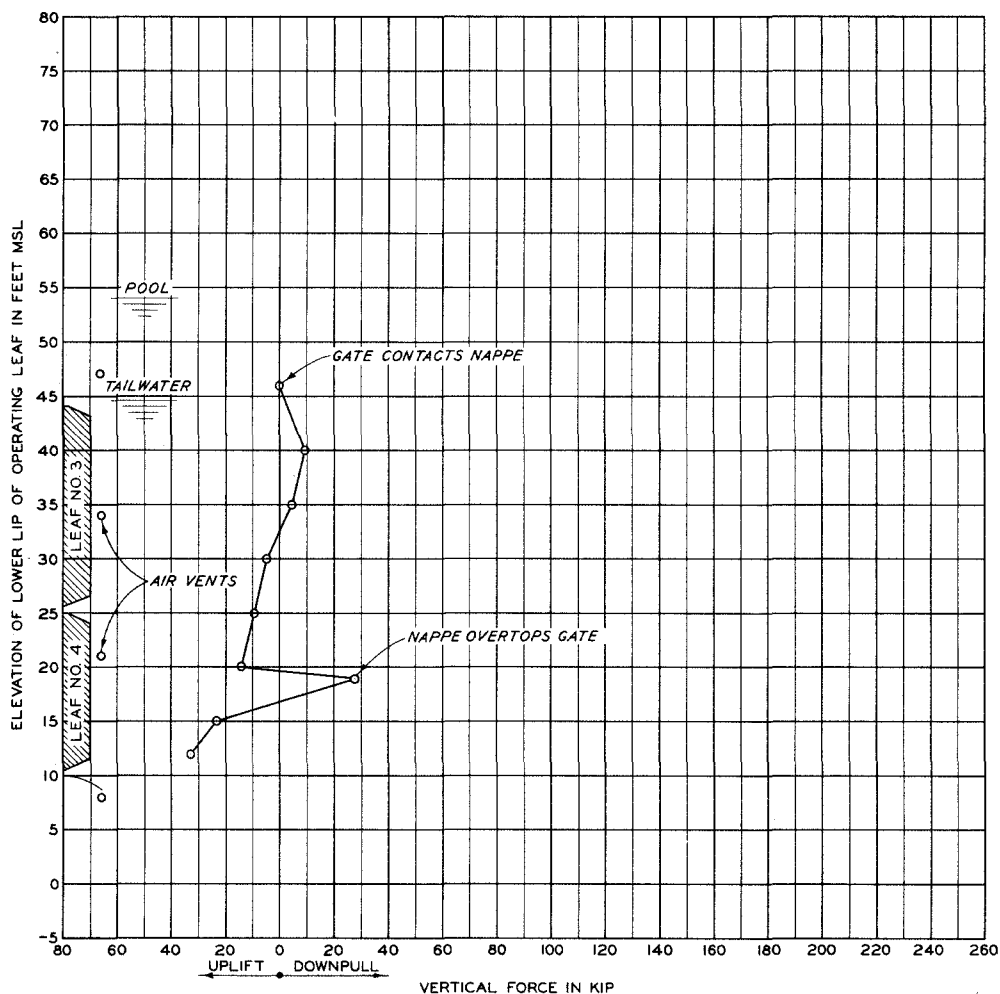
LEGEND

- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 AND GATE LEAF NO. 4
FASTENED TOGETHER AND CLOSING

POOL ELEV 67.0 FT MSL
TAILWATER ELEV 25.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

VERTICAL FORCES PLOTTED ARE EXTERNAL FORCES ACTING UPON THE GATE AS A RESULT OF FLOW OVER AND UNDER IT. IN ORDER TO OBTAIN THE TOTAL HOIST LOAD, THE DRY WEIGHT OF THE GATE SHOULD BE APPLIED TO THE FORCES SHOWN.

ALL BAYS CLOSED EXCEPT BAY NO. 9.

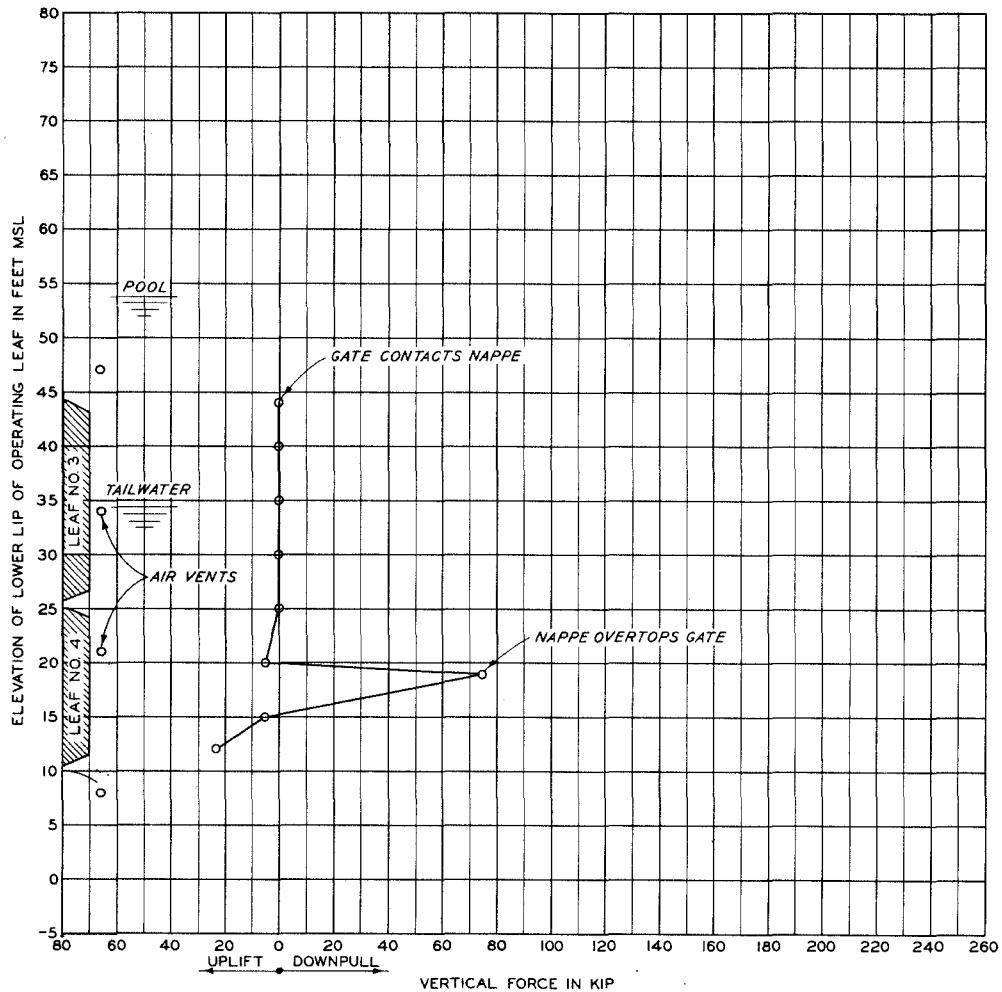
LEGEND

- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 AND GATE LEAF NO. 4
FASTENED TOGETHER AND CLOSING

POOL ELEV 54.0 FT MSL
TAILWATER ELEV 45.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

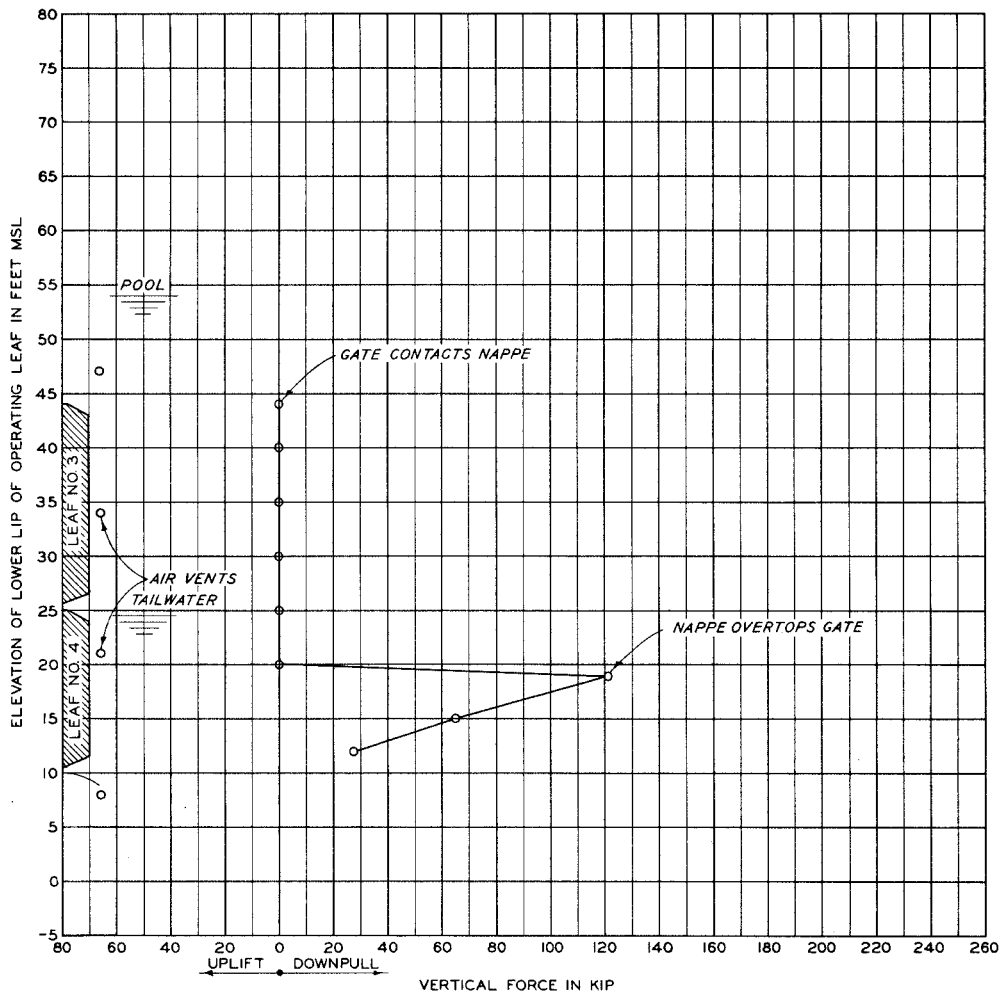
VERTICAL FORCES PLOTTED ARE EXTERNAL FORCES ACTING UPON THE GATE AS A RESULT OF FLOW OVER AND UNDER IT. IN ORDER TO OBTAIN THE TOTAL HOIST LOAD, THE DRY WEIGHT OF THE GATE SHOULD BE APPLIED TO THE FORCES SHOWN.

ALL BAYS CLOSED EXCEPT BAY NO. 9.

LEGEND
 O OBSERVED AVERAGE
 D MAXIMUM
 Δ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 AND GATE LEAF NO. 4
FASTENED TOGETHER AND CLOSING
 POOL ELEV 54.0 FT MSL
 TAILWATER ELEV 35.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

VERTICAL FORCES PLOTTED ARE EXTERNAL FORCES ACTING UPON THE GATE AS A RESULT OF FLOW OVER AND UNDER IT. IN ORDER TO OBTAIN THE TOTAL HOIST LOAD, THE DRY WEIGHT OF THE GATE SHOULD BE APPLIED TO THE FORCES SHOWN.

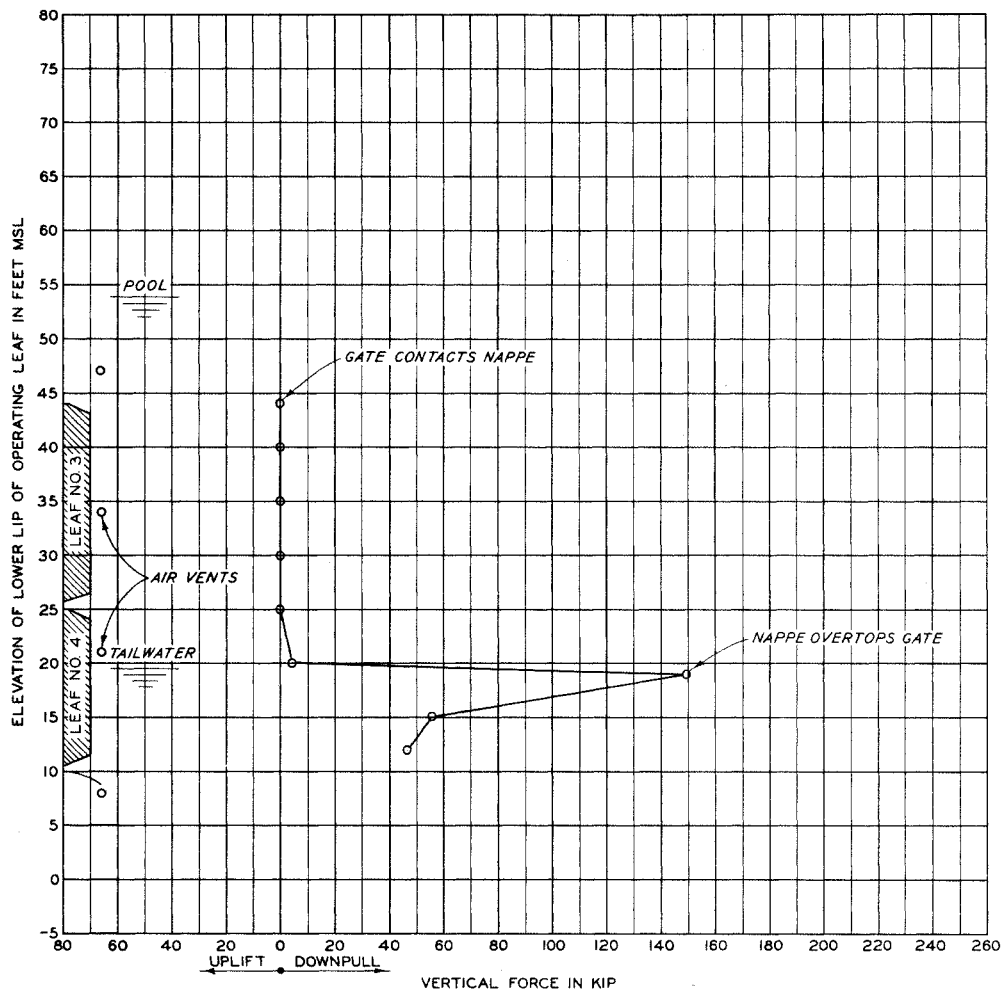
ALL BAYS CLOSED EXCEPT BAY NO. 9.

LEGEND
 O OBSERVED AVERAGE
 □ MAXIMUM
 △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 AND GATE LEAF NO. 4
 FASTENED TOGETHER AND CLOSING

POOL ELEV 54.0 FT MSL
 TAILWATER ELEV 25.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

VERTICAL FORCES PLOTTED ARE EXTERNAL FORCES ACTING UPON THE GATE AS A RESULT OF FLOW OVER AND UNDER IT. IN ORDER TO OBTAIN THE TOTAL HOIST LOAD, THE DRY WEIGHT OF THE GATE SHOULD BE APPLIED TO THE FORCES SHOWN.

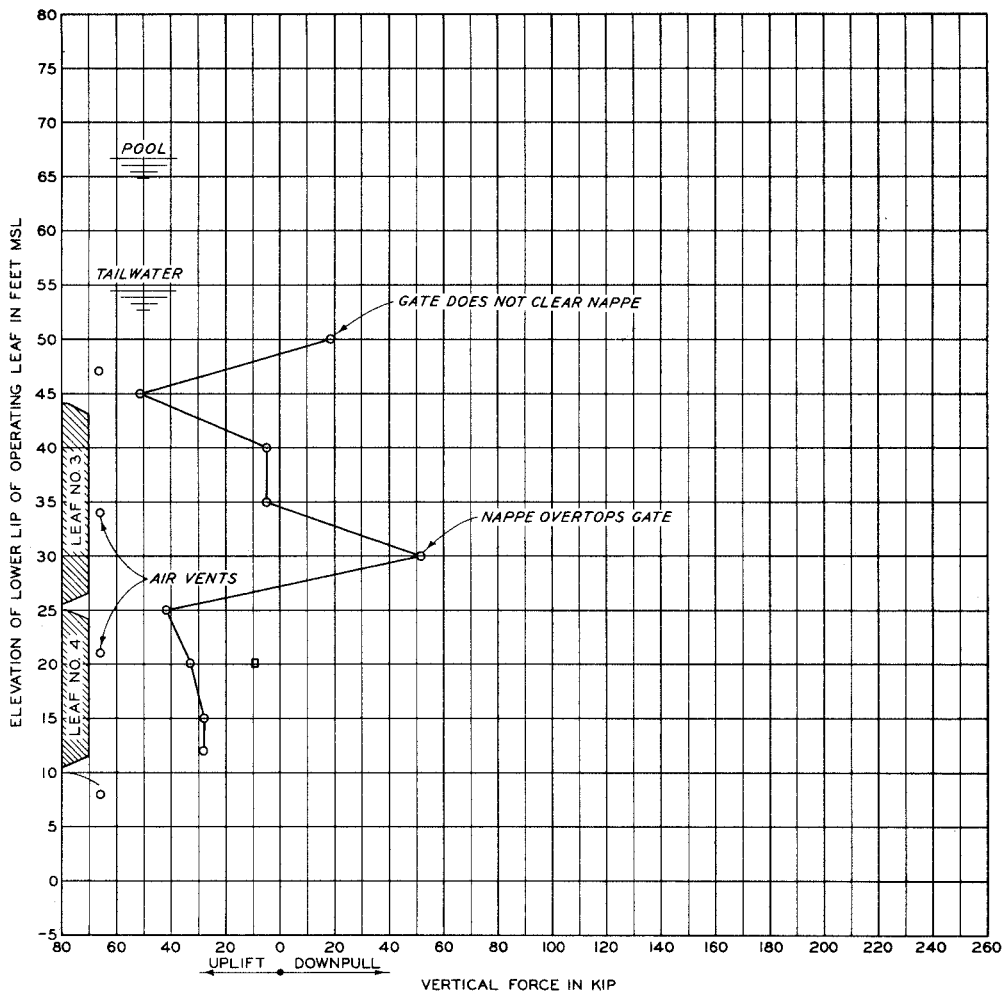
ALL BAYS CLOSED EXCEPT BAY NO. 9.

LEGEND
 O OBSERVED AVERAGE
 □ MAXIMUM
 △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 AND GATE LEAF NO. 4
FASTENED TOGETHER AND CLOSING

POOL ELEV 54.0 FT MSL
TAILWATER ELEV 20.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

VERTICAL FORCES PLOTTED ARE EXTERNAL FORCES ACTING UPON THE GATE AS A RESULT OF FLOW OVER AND UNDER IT. IN ORDER TO OBTAIN THE TOTAL HOIST LOAD, THE DRY WEIGHT OF THE GATE SHOULD BE APPLIED TO THE FORCES SHOWN.

LEGEND

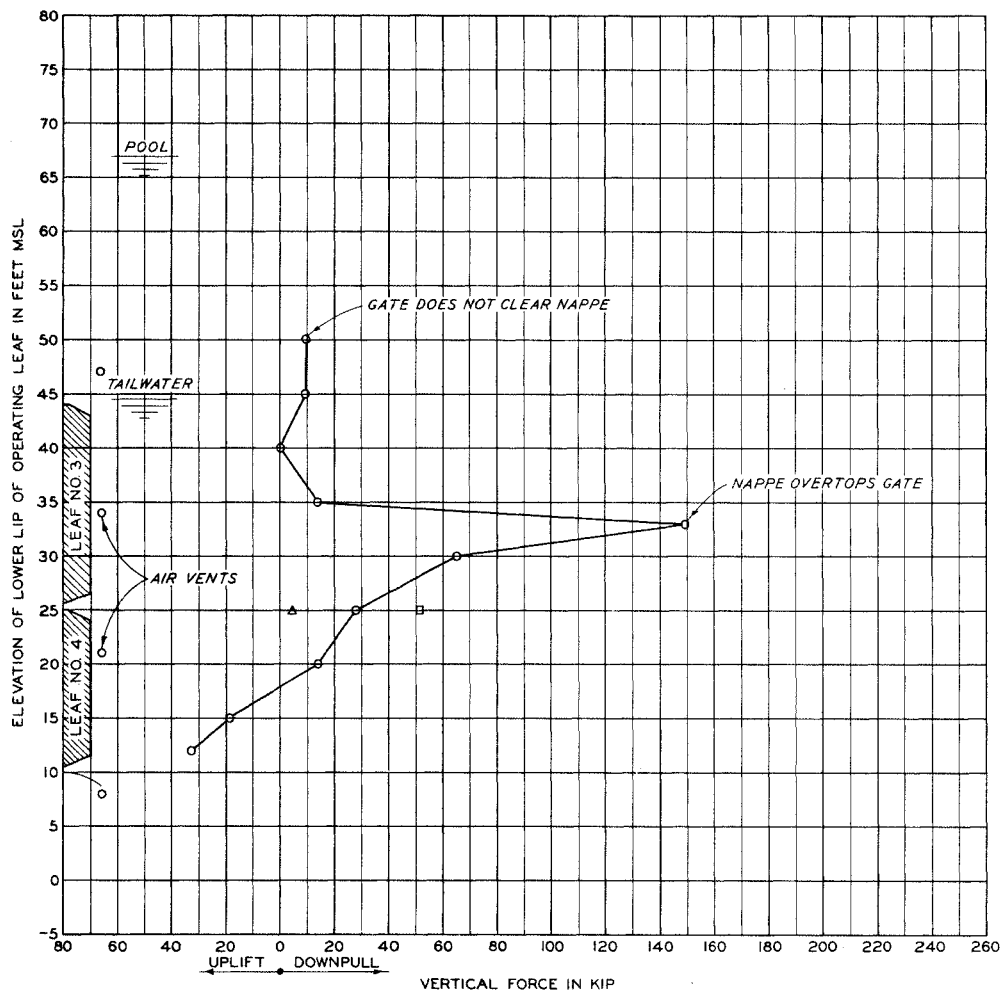
- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 AND GATE LEAF NO. 4
FASTENED TOGETHER AND CLOSING

ALL BAYS CLOSED EXCEPT
BAYS NOS. 8, 9, 10

POOL ELEV 67.0 FT MSL
TAILWATER ELEV 55.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

VERTICAL FORCES PLOTTED ARE EXTERNAL FORCES ACTING UPON THE GATE AS A RESULT OF FLOW OVER AND UNDER IT. IN ORDER TO OBTAIN THE TOTAL HOIST LOAD, THE DRY WEIGHT OF THE GATE SHOULD BE APPLIED TO THE FORCES SHOWN.

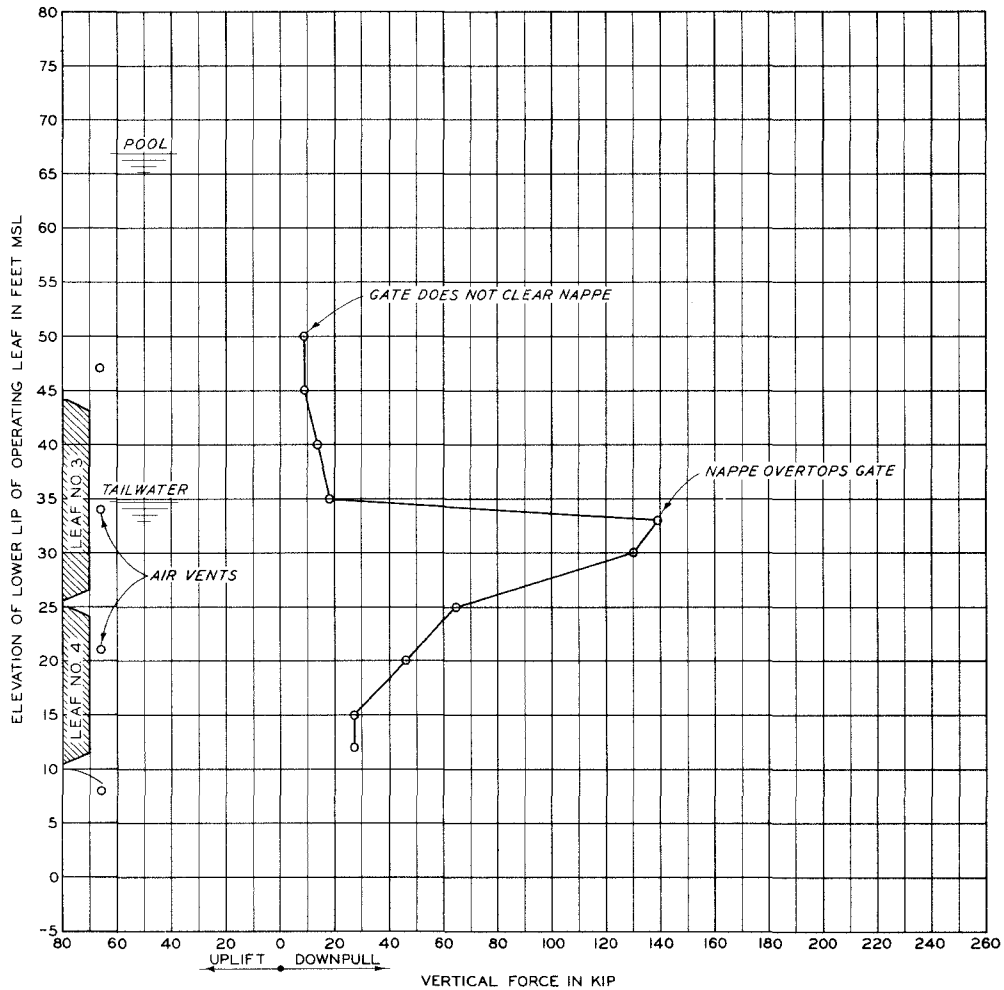
LEGEND
 ○ OBSERVED AVERAGE
 □ MAXIMUM
 △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 AND GATE LEAF NO. 4
FASTENED TOGETHER AND CLOSING

ALL BAYS CLOSED EXCEPT
BAYS NOS. 8, 9, 10

POOL ELEV 67.0 FT MSL
TAILWATER ELEV 45.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

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ALL BAYS CLOSED EXCEPT BAYS NOS. 8, 9, 10.

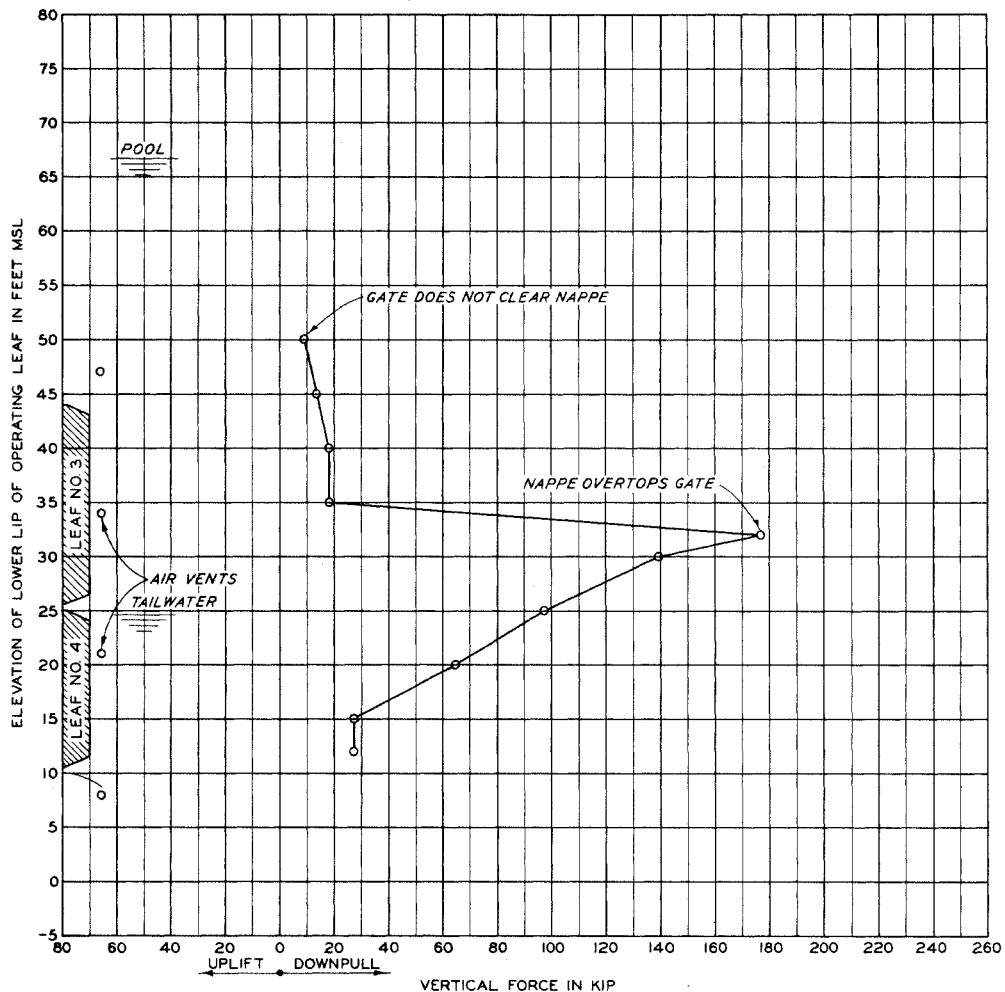
LEGEND

- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 AND GATE LEAF NO. 4
FASTENED TOGETHER AND CLOSING

POOL ELEV 67.0 FT MSL
TAILWATER ELEV 35.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

VERTICAL FORCES PLOTTED ARE EXTERNAL FORCES ACTING UPON THE GATE AS A RESULT OF FLOW OVER AND UNDER IT. IN ORDER TO OBTAIN THE TOTAL HOIST LOAD, THE DRY WEIGHT OF THE GATE SHOULD BE APPLIED TO THE FORCES SHOWN.

ALL BAYS CLOSED EXCEPT BAYS NOS. 8, 9, 10.

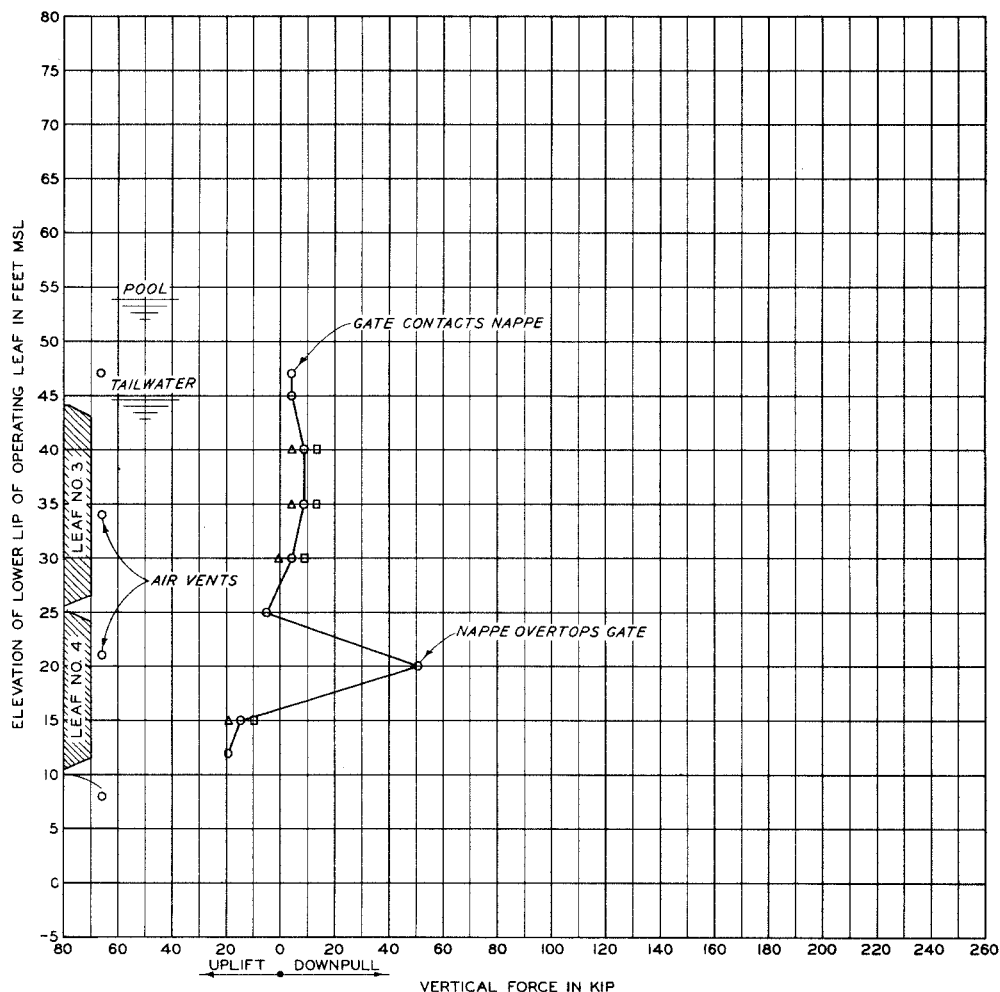
LEGEND

- O OBSERVED AVERAGE
- MAXIMUM
- Δ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 AND GATE LEAF NO. 4
FASTENED TOGETHER AND CLOSING

POOL ELEV 67.0 FT MSL
TAILWATER ELEV 25.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

VERTICAL FORCES PLOTTED ARE EXTERNAL FORCES ACTING UPON THE GATE AS A RESULT OF FLOW OVER AND UNDER IT. IN ORDER TO OBTAIN THE TOTAL HOIST LOAD, THE DRY WEIGHT OF THE GATE SHOULD BE APPLIED TO THE FORCES SHOWN.

ALL BAYS CLOSED EXCEPT BAYS NOS. 8, 9, 10.

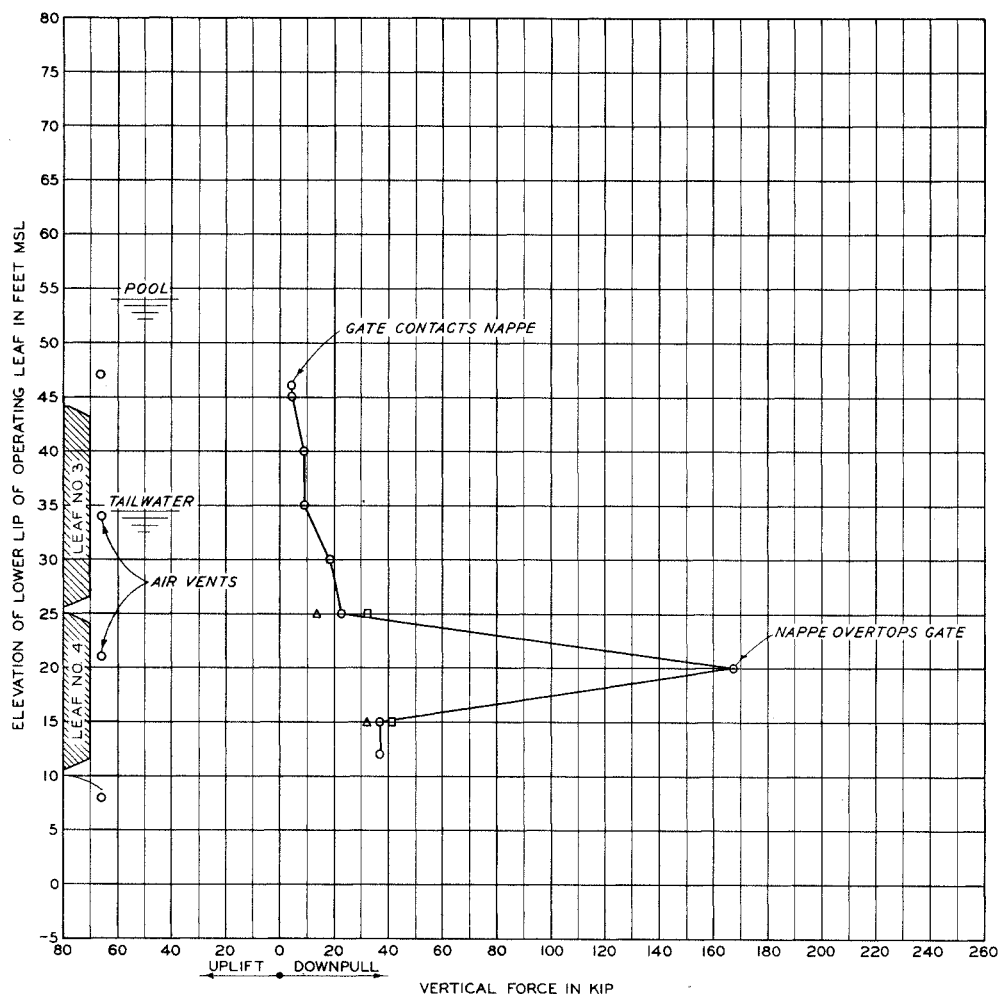
LEGEND

- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 AND GATE LEAF NO. 4
FASTENED TOGETHER AND CLOSING

POOL ELEV 54.0 FT MSL
TAILWATER ELEV 45.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

VERTICAL FORCES PLOTTED ARE EXTERNAL FORCES ACTING UPON THE GATE AS A RESULT OF FLOW OVER AND UNDER IT. IN ORDER TO OBTAIN THE TOTAL HOIST LOAD, THE DRY WEIGHT OF THE GATE SHOULD BE APPLIED TO THE FORCES SHOWN.

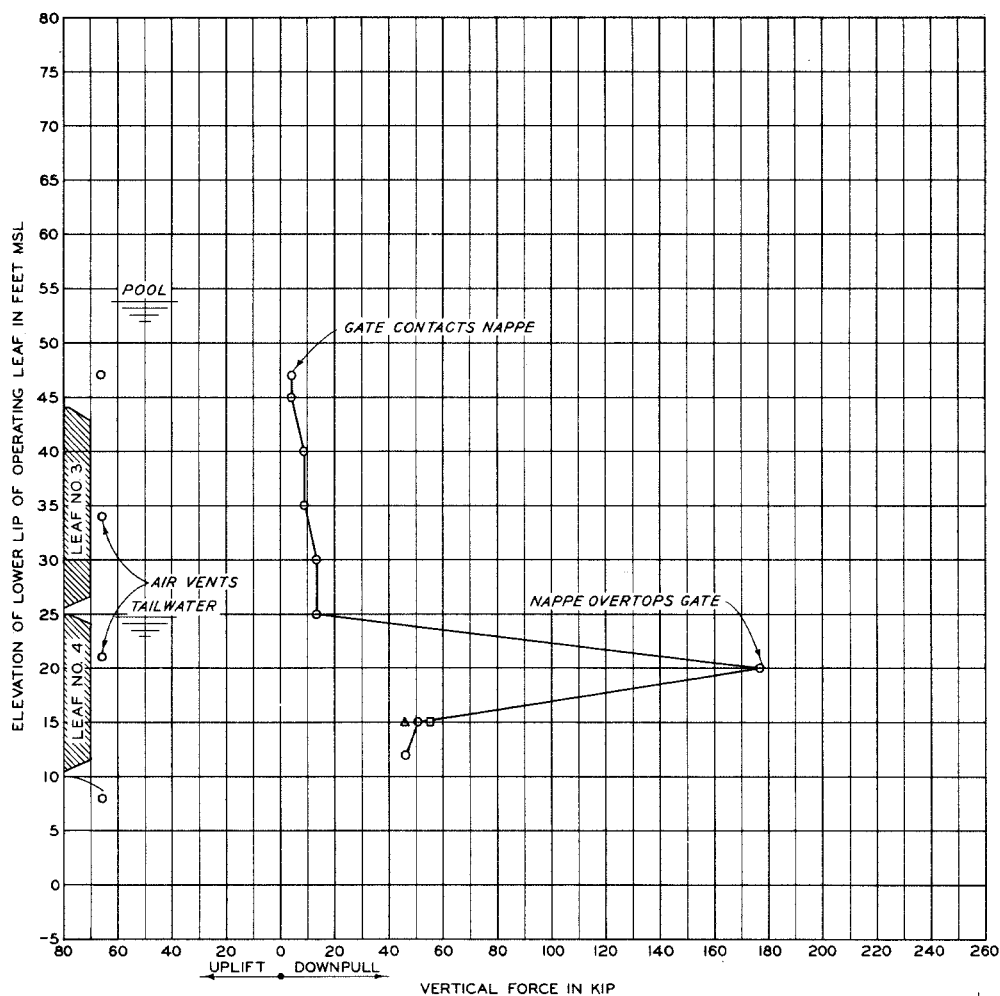
ALL BAYS CLOSED EXCEPT BAYS NOS. 8, 9, 10.

LEGEND
 O OBSERVED AVERAGE
 □ MAXIMUM
 Δ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 AND GATE LEAF NO. 4
FASTENED TOGETHER AND CLOSING

POOL ELEV 54.0 FT MSL
TAILWATER ELEV 35.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

VERTICAL FORCES PLOTTED ARE EXTERNAL FORCES ACTING UPON THE GATE AS A RESULT OF FLOW OVER AND UNDER IT. IN ORDER TO OBTAIN THE TOTAL HOIST LOAD, THE DRY WEIGHT OF THE GATE SHOULD BE APPLIED TO THE FORCES SHOWN.

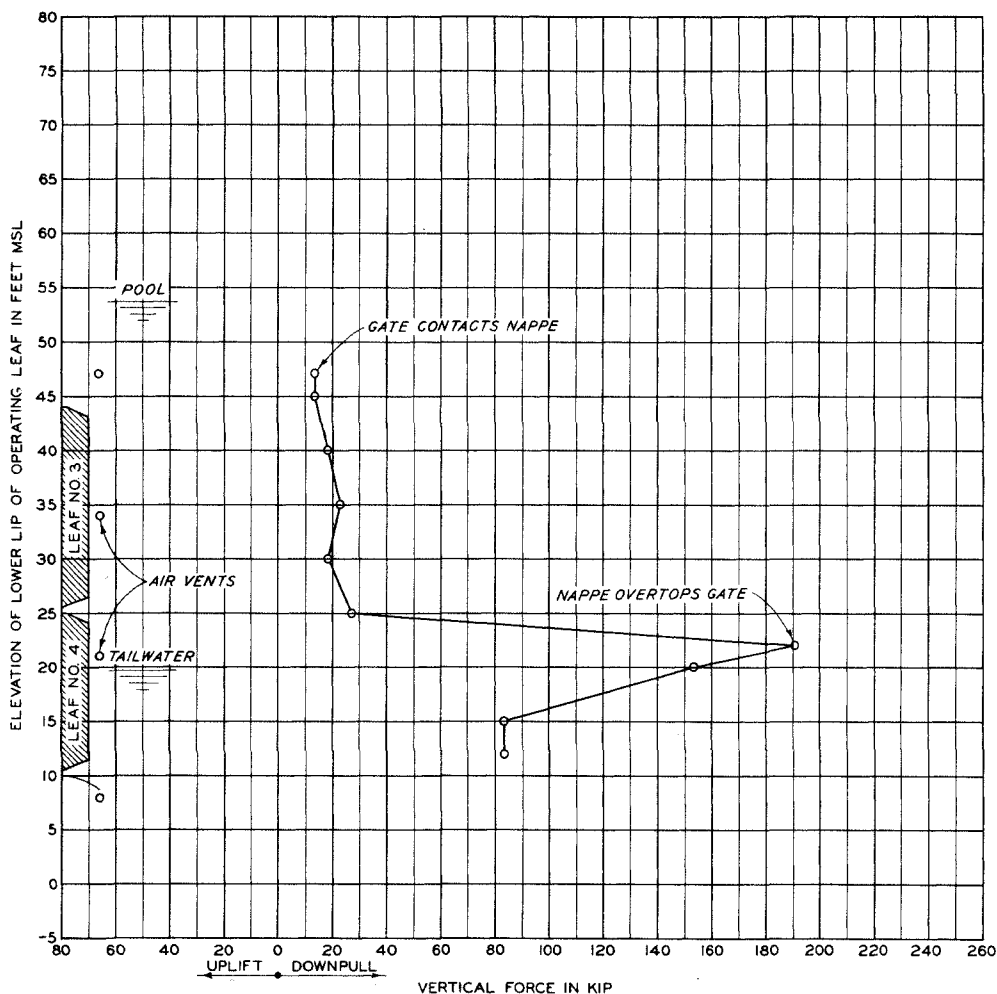
ALL BAYS CLOSED EXCEPT BAYS NOS. 8, 9, 10.

LEGEND
 O OBSERVED AVERAGE
 □ MAXIMUM
 △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 AND GATE LEAF NO. 4
FASTENED TOGETHER AND CLOSING

POOL ELEV 54.0 FT MSL
TAILWATER ELEV 25.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

VERTICAL FORCES PLOTTED ARE EXTERNAL FORCES ACTING UPON THE GATE AS A RESULT OF FLOW OVER AND UNDER IT. IN ORDER TO OBTAIN THE TOTAL HOIST LOAD, THE DRY WEIGHT OF THE GATE SHOULD BE APPLIED TO THE FORCES SHOWN.

LEGEND

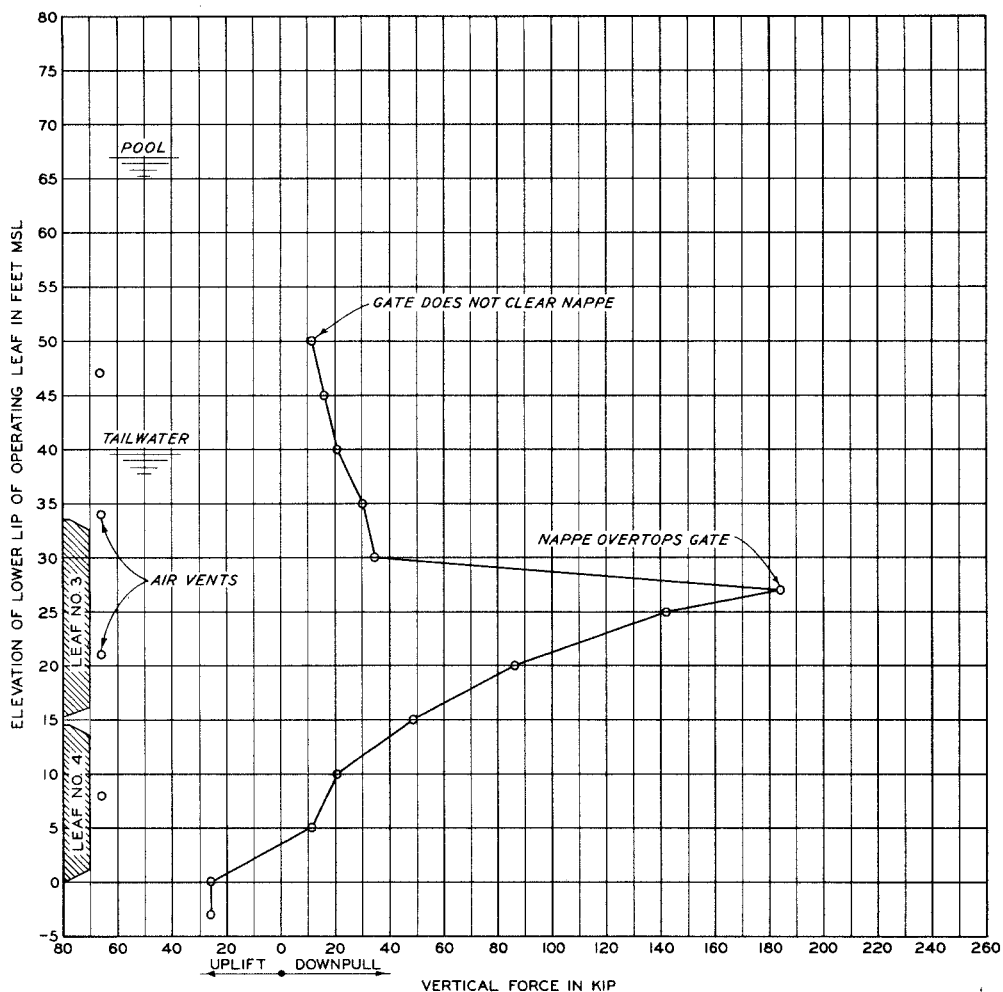
- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 AND GATE LEAF NO. 4
FASTENED TOGETHER AND CLOSING

ALL BAYS CLOSED EXCEPT
BAYS NOS. 8, 9, 10

POOL ELEV 54.0 FT MSL
TAILWATER ELEV 20.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE BOTTOM LEAF. THE UPPER LEAF IS TYPE I (ORIGINAL) DESIGN.

VERTICAL FORCES PLOTTED ARE EXTERNAL FORCES ACTING UPON THE GATE AS A RESULT OF FLOW OVER AND UNDER IT. IN ORDER TO OBTAIN THE TOTAL HOIST LOAD, THE DRY WEIGHT OF THE GATE SHOULD BE APPLIED TO THE FORCES SHOWN.

ALL BAYS CLOSED EXCEPT THREE CENTER BAYS (BAYS NOS. 5, 6, 7).

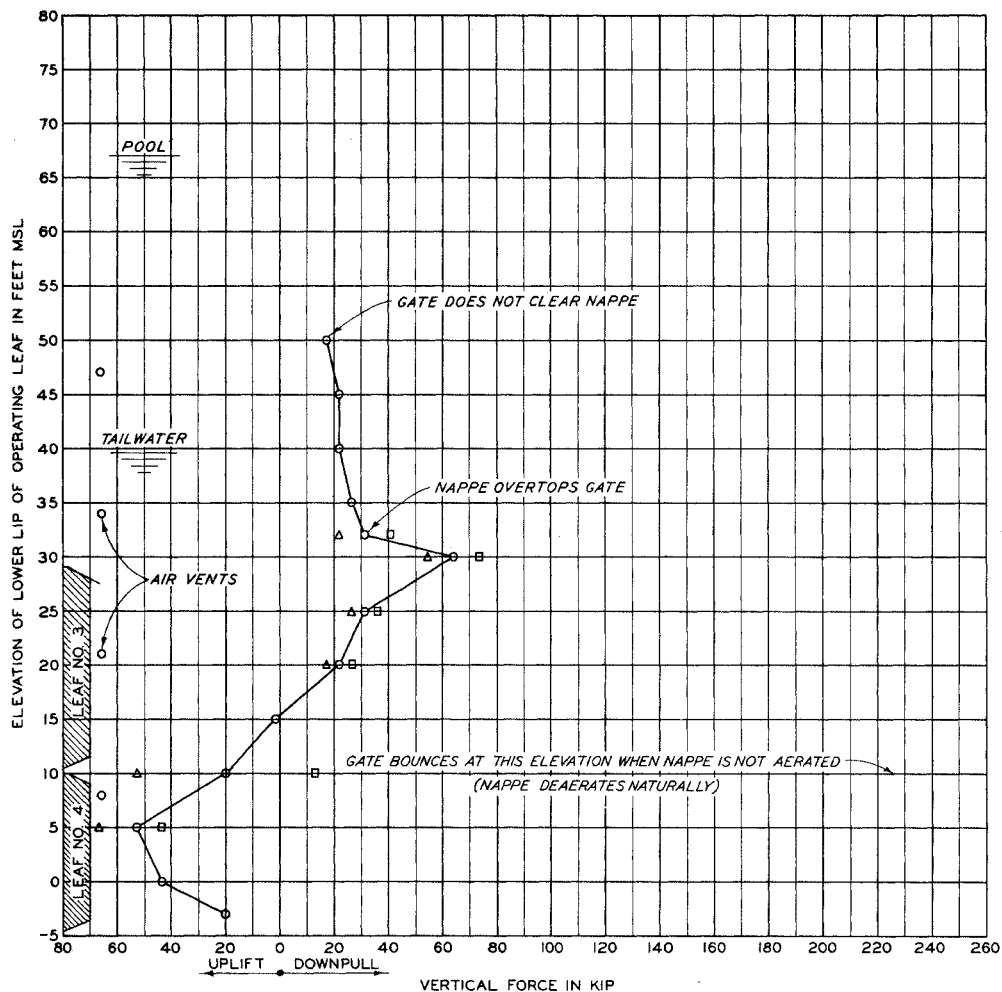
LEGEND

- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I-C GATE LEAF

GATE LEAF NO. 3 AND GATE LEAF NO. 4
FASTENED TOGETHER AND CLOSING

POOL ELEV 67.0 FT MSL
TAILWATER ELEV 40.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

VERTICAL FORCES PLOTTED ARE EXTERNAL FORCES ACTING UPON THE GATE AS A RESULT OF FLOW OVER AND UNDER IT. IN ORDER TO OBTAIN THE TOTAL HOIST LOAD, THE DRY WEIGHT OF THE GATE SHOULD BE APPLIED TO THE FORCES SHOWN.

ALL BAYS CLOSED EXCEPT THREE CENTER BAYS (BAYS NOS. 5, 6, 7).

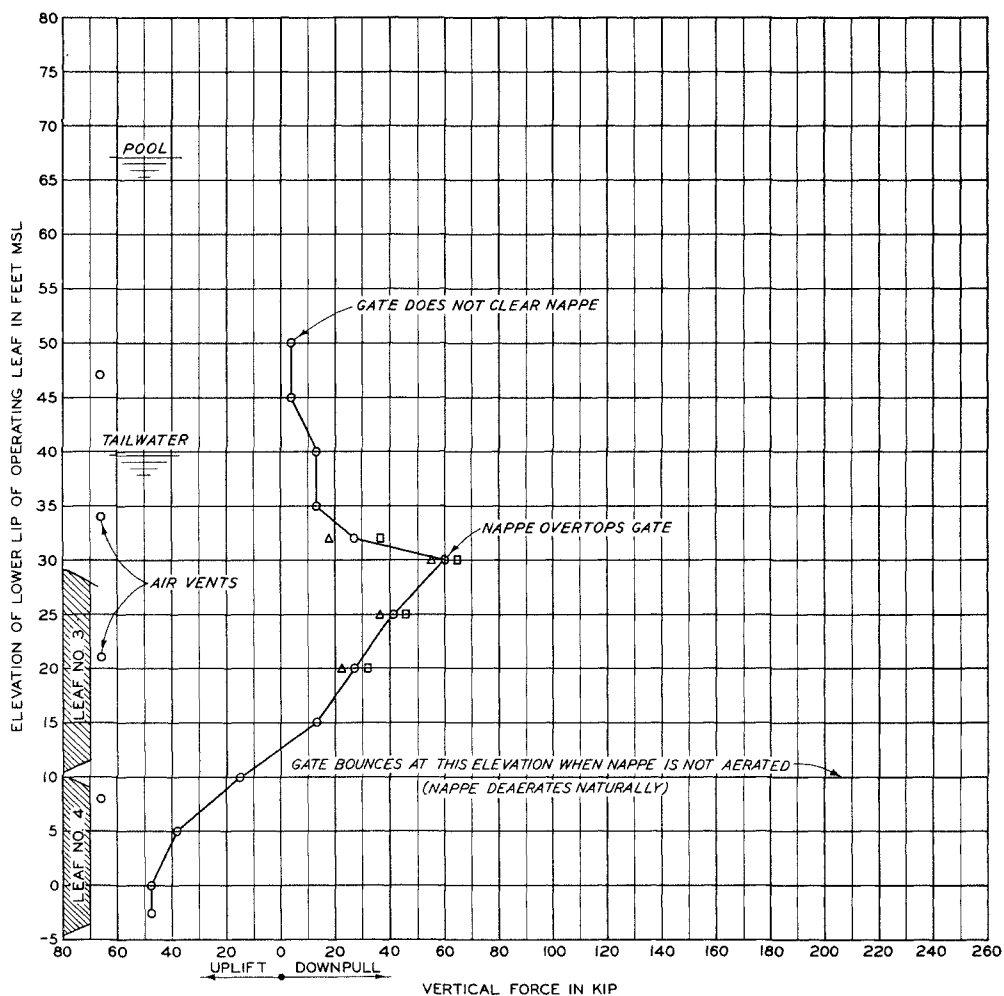
LEGEND

- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE 2-A GATE LEAF

GATE LEAF NO. 3 AND GATE LEAF NO. 4
FASTENED TOGETHER AND CLOSING

POOL ELEV 67.0 FT MSL
TAILWATER ELEV 40.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

VERTICAL FORCES PLOTTED ARE EXTERNAL FORCES ACTING UPON THE GATE AS A RESULT OF FLOW OVER AND UNDER IT. IN ORDER TO OBTAIN THE TOTAL HOIST LOAD, THE DRY WEIGHT OF THE GATE SHOULD BE APPLIED TO THE FORCES SHOWN.

ALL BAYS CLOSED EXCEPT THREE CENTER BAYS (BAYS NOS. 5, 6, 7).

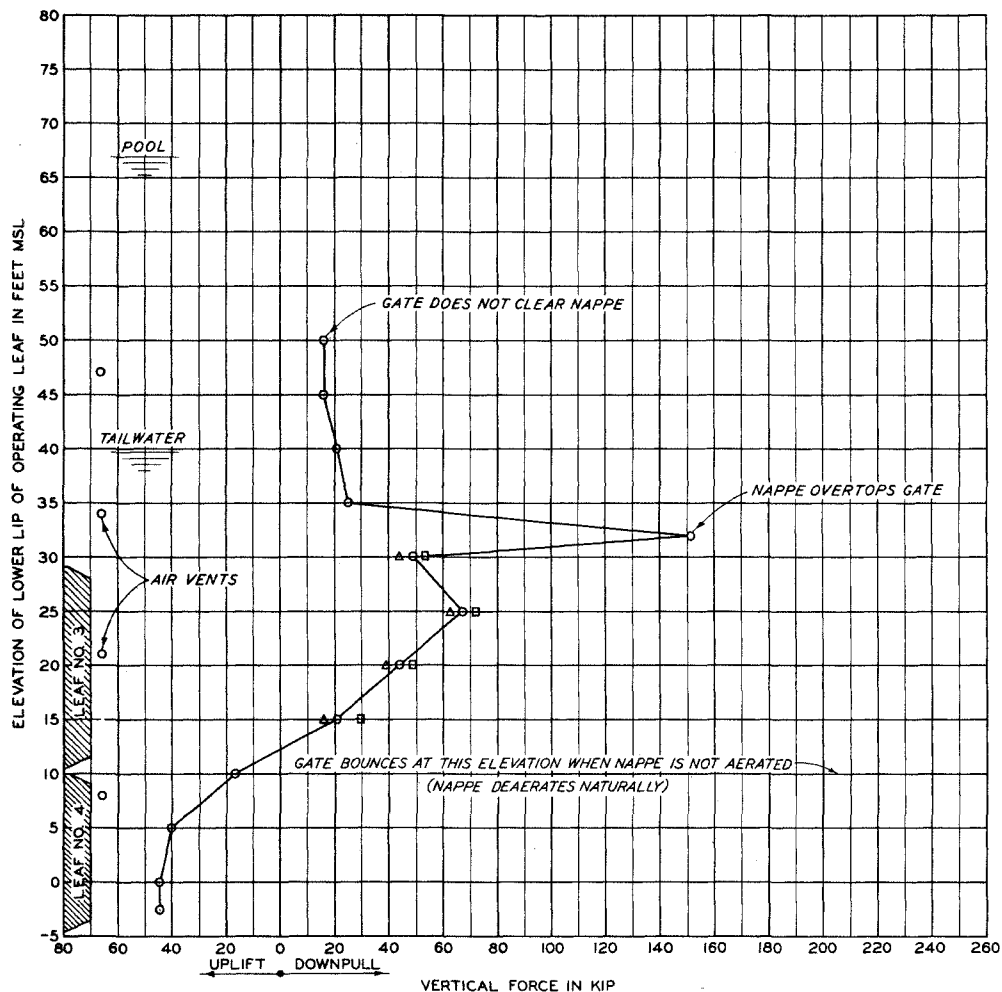
LEGEND

- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE 2-B GATE LEAF

GATE LEAF NO. 3 AND GATE LEAF NO. 4
FASTENED TOGETHER AND CLOSING

POOL ELEV 67.0 FT MSL
TAILWATER ELEV 40.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

VERTICAL FORCES PLOTTED ARE EXTERNAL FORCES ACTING UPON THE GATE AS A RESULT OF FLOW OVER AND UNDER IT. IN ORDER TO OBTAIN THE TOTAL HOIST LOAD, THE DRY WEIGHT OF THE GATE SHOULD BE APPLIED TO THE FORCES SHOWN.

ALL BAYS CLOSED EXCEPT THREE CENTER BAYS (BAYS NOS. 5, 6, 7).

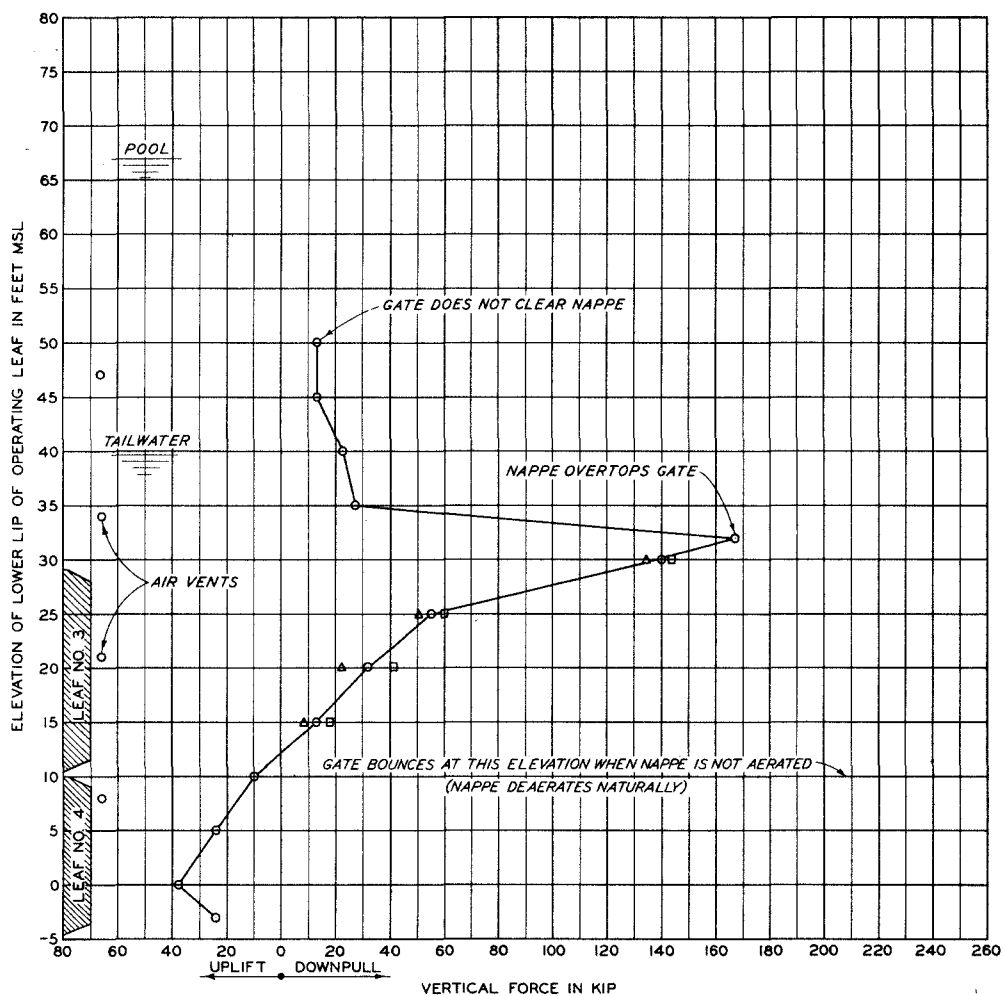
LEGEND

- OBSERVED AVERAGE
- MAXIMUM
- △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE 2-C GATE LEAF

GATE LEAF NO. 3 AND GATE LEAF NO. 4
FASTENED TOGETHER AND CLOSING

POOL ELEV 67.0 FT MSL
TAILWATER ELEV 40.0 FT MSL



NOTE: THE GATE LEAF TYPE SPECIFIED IN THE TITLE REFERS TO THE LEAF WHICH IS OPERATING OR TO THE TOP LEAF WHEN TWO LEAVES ARE FASTENED TOGETHER.

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ALL BAYS CLOSED EXCEPT THREE CENTER BAYS (BAYS NOS. 5, 6, 7).

LEGEND
 ○ OBSERVED AVERAGE
 □ MAXIMUM
 △ MINIMUM

VERTICAL HYDRAULIC FORCE TYPE I (ORIGINAL) GATE LEAF

GATE LEAF NO. 3 AND GATE LEAF NO. 4
FASTENED TOGETHER AND CLOSING
 POOL ELEV 67.0 FT MSL
 TAILWATER ELEV 40.0 FT MSL

REVISED TEST RESULTS